UNIVERSITY OF NOTTINGHAM

REPORT OF THE SCHOOL OF AGRICULTURE

1955

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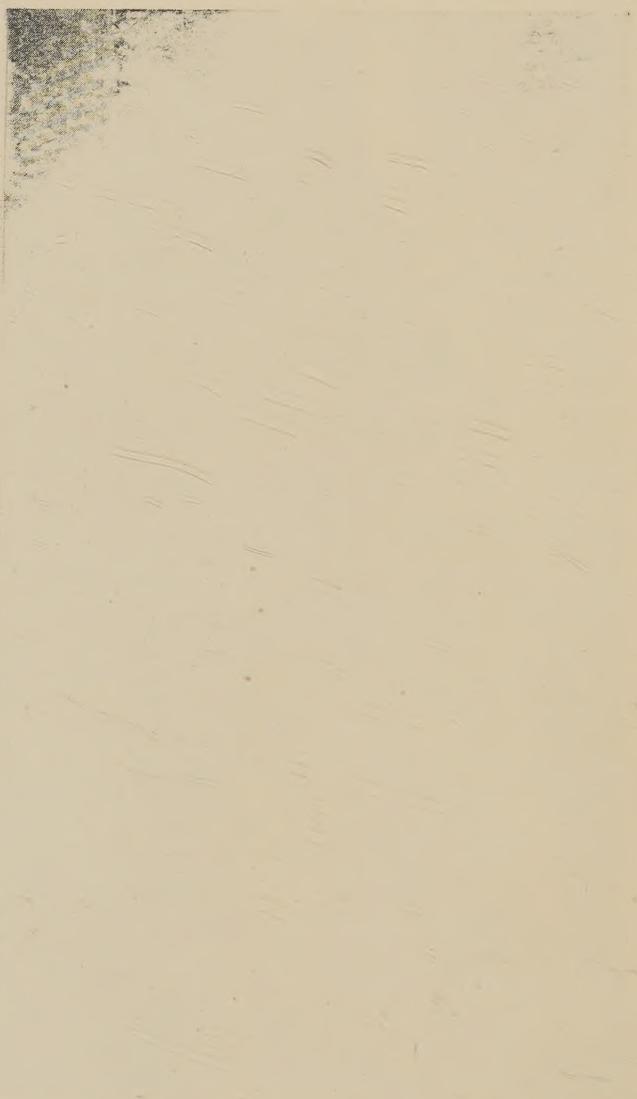

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INTRODUCTION.

THE UNIVERSITY OF NOTTINGHAM SCHOOL OF AGRICULTURE

THE School of Agriculture in its present form came into being in 1947, with the transfer to University College, Nottingham, of the buildings and land formerly held by the Midland Agricultural College. It is situated at Sutton Bonington, eleven miles from the University centre, and houses the four University departments of Agriculture, Agricultural Sciences, Horticulture and Agricultural Economics, and also the Veterinary Investigation Centre of the East Midlands Province.

The estate lies in rolling country in the valley of the River Soar, ten miles south of the city of Nottingham. It consists of about 460 acres of land lying between 100 and 250 feet above sea level, some 300 acres of which are arable. The estate also includes a modern fruit plantation, a market garden, three-quarters of an acre of horticultural glasshouses and one-quarter of an acre of Dutch lights, together with ornamental and sports grounds. At the time of the transfer, the buildings held by the Midland Agricultural College consisted of a central block, including administratiive offices, library, lecture rooms and teaching laboratories for chemistry and biology, and an adjacent house, "The Elms", that had been converted to offices and research laboratories.

The former college had its beginnings in the Department of Agriculture of University College, Nottingham (founded in 1893) and in the Midland Dairy Institute (founded in 1895), which were combined to form the Midland Agricultural and Dairy Institute in 1900. In 1906 the title was changed to College, but for the first thirty years of its existence the main emphasis of its work remained the provision of certificate and diploma courses in Agriculture, Dairying and Poultry Husbandry. In 1942 a Horticultural Department was added, and in 1943 collaboration between the Midland Agricultural College and the University College led to the establishment of the Faculty of Agriculture and Horticulture, which was followed four years later by the transfer of the college to the University College authorities in 1947.

The Chair in Agriculture was created in 1943 when H. G. Robinson, then Principal of the College, became the first Professor of Agriculture.

Since 1947, in conformity with the recommendations of the Loveday Report the diploma courses have been curtailed and certificate courses terminated. The diploma course in Agriculture was terminated in 1948, that in Horticulture in 1954 and that in Poultry Husbandry in 1955. At the same time the staff and facilities for degree and post-graduate teaching have been steadily built up and two new Chairs created, Agricultural Chemistry in 1949 and Agricultural Botany in 1953.

Because of the building difficulties of the post-war period, it has not been possible yet to expand the permanent laboratory blocks in the manner originally anticipated, but considerable expansion into temporary buildings and conversion of existing ones has taken place. In 1952 the University took over St. Michael's House, situated on the boundary of the property, and adapted it as the Department of Agricultural Economics, whilst "The Elms" has been developed to house the Veterinary Investigation Centre for the East Midlands, the Potato Storage Unit of the Agricultural Research Council, and the research laboratories of the Agricultural Zoology and Animal Physiology sections. Since then, in addition to the temporary laboratories, a milk-products laboratory has been built in the Dairy, small-scale plant growth rooms have been built for the Departments of Horticulture and Agricultural Sciences and a new range of glasshouses built for experimental work. The glasshouses include two designed for general work on plant nutrition and plant physiology, and one fly-proof glasshouse for entomology.

In 1954, one of the farms held by the University, Lodge Farm, was reconstructed as a field experimentation unit equipped for work in various aspects of crop and animal husbandry, and includes a slaughter-house and cold room, small-animal houses, metabolism room, field laboratory and range of feeding pens. The object of this unit is to provide facilities for research for all sections of the Agriculture and Agricultural Sciences Departments. It also includes a crop testing station of the National Institute of Agricultural Botany, and an extensive series of potato variety demonstration plots for the Ministry of Agriculture. The livestock are maintained solely for research and comprise a dairy herd of identical twin heifers, a small flock of Clun ewes, a few milking cows and small livestock, such as rabbits and rats which are used for assay and preliminary experimentation. A herd of Large White pigs was established in 1955.

Some 350 acres, based on the Manor Farm, Kingston, is run as a commercial farm with a completely separate labour force, and is

used to demonstrate the techniques of farm management appropriate to the district.

The objectives of the School are twofold, to enlarge the stock of knowledge relating to Agriculture in its widest sense, and to disseminate it by means of undergraduate and post-graduate courses. The University of Nottingham maintains at the School courses of instruction for the degree of B.Sc. and candidates admitted to such courses may qualify for honours degrees in Agriculture, Agricultural Botany, Agricultural Chemistry, Agricultural Microbiology, Agricultural Zoology or Horticulture, or for pass degrees in Agriculture, Dairying or Horticulture. Courses are also given leading to diplomas in Dairying. Enrolment for the current year included 158 students for first degree courses, and 19 students for post-graduate courses.

The Department of Agricultural Economics is a part of the Provincial Agricultural Economics Service for England and Wales, and is responsible to the Ministry of Agriculture, Fisheries and Food for the supply of economic data about agriculture in the East Midlands. It is at the same time responsible for advisory and extension work in agricultural economics and farm management throughout the East Midlands Province.

Apart from the work of this one department, extension work in agriculture is not a function of the School, although some is effected through visits of Young Farmers' Clubs, parties of farmers and other visitors to the experimental and demonstration fields and to the laboratories, and by lectures given by members of the staff to farmers' and growers' organisations. During the period under review members of staff have co-operated with the B.B.C. in giving talks on the Home and Television services.

The scientific work of the School centres around the study of the principles of crop and animal husbandry, and of the problems which may be associated with them. Expressed in more precise terms, the aim is to conduct researches on soil, plant and animal problems relating to agriculture and horticulture and on the insect pests which affect production. Certain aspects of the work in progress, which has reached a stage suitable for review, are described in a later part of this report.

The scientific work of the School is mainly financed from general University funds, but in the last two years specific investigations have been aided by grants from other organisations. Since 1953 the Agricultural Research Council has assisted investigations at the

School. The Department of Horticulture received £500 in 1953, £1,098 in 1954 and £1,130 in 1955 to support investigations into the water relationships of plants grown under glass and various aspects of the regeneration of plants from leaves and roots. The Agricultural Research Council has also helped to finance the investigations into aphid migration being carried out by the Agricultural Zoology Unit of the Department of Agricultural Sciences, and has provided £765 in 1954 and £1,035 in 1955. The Medical Research Council gave £900 in 1954 and 1955 for investigations by the Microbiology Unit into the synthesis of fat by micro-organisms. In 1955 the Fison Research Fellowship for work in Soil Science and Plant Nutrition was created by Fisons Limited, who have undertaken to give £750 a year for the next three years. In 1955 also, Boots Pure Drug Company gave a Judd-Lewis comparator, value £100, to assist in the establishment of the spectrographic laboratory.

At the instigation of the Electrical Development Association, the East Midlands Electricity Board have provided an electrical grass dryer, valued at £1,000, on permanent loan to the Department of Agriculture, which has also received £200 from The British Oil and Cake Mills Limited, to assist investigations into the effect of hormones on growth and carcase quality of cattle. Generous assistance has also been forthcoming from many other firms who have given supplies of hormones and antibiotics. The Department of Agricultural Economics has also received a grant of £3,000 in 1953 from Counterpart Funds for an inquiry into methods of improving the productivity of labour in horticultural production.

Grateful acknowledgment is also made to Members of the Institute of Corn and Agricultural Merchants, Mr. Wesley Weightman, J.P., Rotary Hoes, Ltd., Steel Fabricators, Ltd. and W. N. Nicholson and Sons, Ltd. for gifts of stock and equipment.

THE UNIVERSITY OF NOTTINGHAM SCHOOL OF AGRICULTURE

Vice-Chancellor :

Bertrand Leslie Hallward, D.L., M.A.

Deputy Vice-Chancellor :

Professor Leslie Fleetwood Bates, Ph.D., D.Sc., F.R.S.

Registrar :

Hedley Pickbourne, M.A.

Assistant Registrar and Secretary to the Faculty Board :

Alfred Plumb, M.A.

ADVISORY COMMITTEE

Alderman J. W. F. Hill, C.B.E., M.A., LL.M., Litt.D.
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Mr. R. M. Chambers, B.Sc., B.Agr.
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Mr. J. F. D. Hargreaves.
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Alderman M. Holland, C.B.E., J.P.
Mr. C. E. Horton, M.Sc.

Dr. J. P. Hudson, M.B.E., G.M., M.Sc., N.D.H.

Dr. J. D. Ivins, M.Sc.

Mr. P. Lyth, B.Sc.

Mr. P. S. Marsden, M.C., M.A.

Professor F. L. Milthorpe, M.Sc. Agr., Ph.D., D.I.C.

Mr. P. A. Missen, M.A., Dip. Agric.

Alderman A. D. Potter, O.B.E.

Mr. K. Rasmussen, Cand. polit.

Mr. J. W. Rowland, N.D.A., N.D.P.

Mr. B. Savage.

Mr. E. F. R. Stearn, M.A., M.Sc.

Alderman G. E. Taylor, C.B.E., M.A., J.P.

Mr. J. B. Thomas.

Mr. H. Pickbourne, M.A. (Registrar)-Secretary to the Advisory Committee.

STAFF.

DEPARTMENT OF AGRICULTURAL SCIENCES

Dean of the Faculty and Head of the Department :

E. G. Hallsworth, B.Sc., Ph.D. (Leeds), A.R.I.C.

Agricultural Chemistry :

Professor :	E. G. Hallsworth, B.Sc., Ph.D. (Leeds), A.R.I.C.
Lecturers :	
Soil Chemistry	D. V. Crawford, M.A., B.Sc., (Oxford)
Dairy Chemistry	E. R. Ling, M.Sc., (London), Ph.D. (Nottingham), A.R.C.S., F.R.I.C.
Bio-chemistry	H. A. Robertson, B.Sc., Ph.D. (Edinburgh), A.R.I.C.
Analyst :	A. C. Burns, M.Sc. (Manchester), F.R.I.C.
Demonstrator :	E. A. N. Greenwood, B.Agr. Sci. (Melbourne), D.D.A.
University Research Fellow :	I. Rorison, B.A.*
Research Assistant :	Jane B. Auden, B.Sc. (Bristol)

Agricultural Botany :

Professor :	F. L. Milthorpe, M.Sc. Agr. (Sydney) Ph.D. (London), D.I.C.
Lecturers :	
Agricultural Botany	K. W. Dent, B.Sc., Ph.D. (Birmingham)
	Miriam M. Edwards, B.Sc., Ph.D. (Manchester)
Plant Pathology	T. H. Nicolson, B.Sc. (Agric.) (Aberdeen), Ph.D.(Nottingham)

* Commencing duties in January 1956.

Assistant Lecturer :	
Genetics	W. J. Whittington, B.Sc. (Wales)
Demonstrator :	Margaret E. Protheroe, B.Sc. (Wales)
University Research Fellow :	D. E. G. Sheat, M.Sc. (New Zealand)
Agricultural Microbiology :	
Lecturer :	M. Woodbine, M.Sc., Ph.D. (Manchester) F.R.I.C.
Assistant Lecturers :	Anne B. Dickinson, B.Sc. (Agric.) (Durham).
	A. Seaman, B.Sc. (London), Ph.D. (Nottingham)
Research Fellow : (*i*)	J. W. Hopton, M.Sc. (Tech.) (Manchester)
Agricultural Zoology :	
Lecturers :	D. K. McE. Kevan, B.Sc. (Edinburgh), A.I.C.T.A. (Trinidad)
	C. E. Taylor, B.Sc. (Wales), Ph.D. (Nottingham)
Demonstrator :	D. Lomas, B.Sc. (Liverpool)
Research Assistant (*ii*)	J. Y. Ritchie, B.Sc. (Agric.) (Glasgow)
Dairying :	
Lecturer and Head of Sub-Department :	R. Scott, B.Sc. (Agric.) (Nottingham), N.D.A., N.D.D.
Lecturer :	M. Stein, LL.D (Prague), B.Sc., Ph.D. (Leeds)
Assistant Lecturer :	Eunice W. Whitt, B.Sc. (Reading)
Departmental Assistant :	Anne C. Hall, N.D.D.

(*i*) Financed by the Medical Research Council.

(ii) Financed by the Agricultural Research Council.

DEPARTMENT OF AGRICULTURE

Lecturer in Crop Husbandry and Acting Head of Department :	J. D. Ivins, B.Sc. (Reading), M.Sc. (Agric.), Ph.D. (Nottingham)
Lecturers :	
Agricultural Engineering	J. Chatterton, D.F.C., B.Sc. (London)
Animal Physiology	G. E. Lamming, B.Sc. (London), M.S., Ph.D. (Illinois), N.D.A. (Hons.)
Animal Husbandry	J. T. Morgan, M.Sc. (Wales), Ph.D. (Nottingham), A.R.I.C.
Poultry Husbandry :	R. B. Shaw.
	E. W. Nightall, N.D.P.
Part-time Lecturers :	
Book-keeping	H. Harris, B.Sc. (Econ.) (London) D.P.A.
Building Construction	O. D. Maguire, A.I.A.S., M.R.San.I.
Honorary Lecturers :	
Veterinary Hygiene	J. C. Buxton, B.Sc., Ph.D. (Nottingham), M.R.C.V.S.
	Connie M. Ford, M.R.C.V.S.
Assistant Lecturer :	
Crop Husbandry	Jean Dilnot, B.Sc. (Wales)
Departmental Assistant :	M. Eddowes, B.Sc. (Agric.) (Reading)
Superintendent of Potato Trials:	Nora McDermott, M.B.E., M.Sc. (Agric.) (Nottingham)
Regional Trials Officer (National Institute of Agricultural Botany)	T. Webster, B.Sc., (Agric.) (Glasgow) N.D.A., Dip. Agri. Science (Aberystwyth)

DEPARTMENT OF HORTICULTURE

Senior Lecturer and Head of Department :	J. P. Hudson, M.B.E., G.M., B.Sc. (Hort.), M.Sc. (London), Ph.D. (Nottingham), N.D.H.
Lecturers :	Margaret E. Marston, B.Sc. (London) M.Sc. (Hort.) (Nottingham), N.D.H.
	W. Heydecker, B.Sc., (Hort.) (Reading), M.Sc. (Nottingham), N.D.H. (Hons.)
Assistant Lecturer :	Winifred M. Dullforce, B.Sc. (Nottingham), N.D.H.
Demonstrator :	I. H. Williams, B.Sc. (Hort), M.Sc. (Nottingham)
Research Assistant : (ii)	J. A. Mackenzie, B.Sc. (Nottingham)

DEPARTMENT OF AGRICULTURAL ECONOMICS

Senior Lecturer and Provincial Agricultural Economist :	K. Rasmussen, Cand. polit. (Copenhagen)
Senior Agricultural Economists :	R. B. Jones, M.Sc. (Wales)
	E. Mejer, M.Sc. (Vilno), M.Sc. (Agric.) (Nottingham)
	W. S. Senior, B.Sc. (Agric.) (Leeds)
Agricultural Economists :	R. O. Wood, M.Sc. (London)
	K. A. Ingersent, B.Sc. (Aberdeen), M.S. (Minnesota)
	R. G. Mortimer, B.Sc. (Wales)
Assistant Agricultural Economists :	R. W. T. Hunt, B. Com. (Liverpool)
	Margaret M. Sandilands, B.A. (London)
	T. W. D. Theophilus, B.Sc. (Wales)
	A. Brown, B.Sc. (Nottingham)
Research Assistant : (iii)	T. K. Warley, B.Sc. (Hort.) (Nottingham)

(*ii*) Financed by the Agricultural Research Council.
(*iii*) Financed by Ministry of Agriculture (Counterpart Funds).

OFFICERS OF THE SCHOOL OF AGRICULTURE

Secretary to the School of Agriculture :	H. Harris, B.Sc. (Econ.) (London) D.P.A.
Surveyor :	O. D. Maguire, A.I.A.S., M.R.San.I.
Librarian :	Nancy W. Rhodes, B.A. (London), A.L.A.
Farm Manager :	A. C. Thompson.
Horticulture Manager :	F. C. Johnson, B.Sc. (Agric.) (Edinburgh)
Dairy Supervisor :	R. Kay.
Executive Assistant :	Muriel I. Wood.
Senior Laboratory Steward :	F. C. Treeby.

POST-GRADUATE STUDENTS

	Subject	Degree
N. Ahmad, M.Sc. (Brit. Columbia) A.I.C.T.A.	*Agricultural Chemistry*	Ph.D.
D. Aspinall, B.Sc. (Nottingham)	*Agricultural Botany*	Ph.D.
A. R. Bird, B. Agr. Sc. (Queensland)	*Agricultural Economics*	M.Sc.
A. W. J. Broome, B.Sc. (Nottingham)	*Animal Physiology*	Ph.D.
D. G. Burch, B.Sc. (Aberystwyth)	*Agricultural Botany*	Ph.D.
T. D. Burgess, M.S.A. (Toronto)	*Animal Husbandry*	Ph.D.
D. W. T. Clay, B.Sc. (Nottingham)	*Horticulture*	M.Sc.
J. I. Coates, B.Sc. (Nottingham)	*Animal Physiology*	Ph.D.
W. F. Coulson, B.Sc. (Nottingham)	*Agricultural Chemistry*	Ph.D.
T. K. Fahmy, B.Sc. (Agric.), M.Sc. (Dairying) (Cairo)	*Agricultural Microbiology*	M.Sc.
J. S. M. Hutchinson, B.Sc. (Nottingham), Dip. Agric. Sc. (Cambridge)	*Agricultural Chemistry*	Ph.D.
E. J. M. Kirby, B.Sc. (Durham)	*Agricultural Botany*	Ph.D.
R. Lahiri, M.Sc. (Calcutta)	*Agricultural Chemistry*	Ph.D.
A. M. Majmudar, B.Sc. Agri. (Poona)	*Horticulture*	Ph.D.
V. J. Montague, B.Sc. (Nottingham)	*Agronomy*	M.Sc.
G. Norton, B. Sc. (Nottingham)	*Agricultural Chemistry*	Ph.D.
M. P. Singh, B.A. (Patna)	*Agricultural Zoology*	M.Sc.
C. D. Sutton, B.Sc. (Nottingham)	*Agricultural Chemistry*	Ph.D.
P. Wix, B.Sc. (Nottingham)	*Agricultural Microbiology*	Ph.D.

THE WORK OF THE SCHOOL OF AGRICULTURE

The problems in agriculture fall into several groups which can be enumerated briefly as :

(a) Soil topics—investigations into the nature and distribution of soils and of the processes responsible for their formation.

(b) Factors affecting plant growth—water relations, mineral nutrition, cultural practices, weed competition, etc.

(c) Factors affecting animal growth and reproduction—nutrition, the level and effect of different hormones.

(d) Problems connected with the effect of insects and other invertebrates.

(e) Microbiological problems affecting either plant or animal health, or concerning the utilisation of agricultural products.

(f) Farm management and returns in relation to the national economy.

The investigations in progress in each of the fields are reported briefly below, and more complete accounts of certain topics are given later.

Soil studies.

Investigations have been made of some soil types occurring in the East Midlands on Keuper Marl, Bunter Sandstone, fluvo-glacial gravel and boulder clay, and the soils encountered related to world groups. Most of the soils appear to be representatives of the Brown Earth group. Podsols occur in a limited area of the Bunter sandstone, and much more widely in the wetter regions to the west. The process by which iron is mobilised in the podsolic soils has been further investigated and the results described later. Investigations have also been made of the mobilization and migration of clay particles in soils. The results obtained showed that although sodium deflocculated the clay much more strongly than calcuim, the deflocculation was so marked that water percolation was greatly restricted, and there was consequently less movement than had been anticipated from the generally accepted theories. The effect of clay mineral was important, and 5% of a montmorillonoid type clay was as effective as 40% of a kaolinitic type in preventing percolation.

Factors affecting plant growth.

Many of the practices of the farmer and horticulturalist are traditional, and represent the accumulated experience and slow modification of many centuries. In more recent times the rapid advance

in many branches of knowledge have called into question the validity of some of these practices, and several studies have been made in the School of the manner in which cultural practices affect the growth of the plant.

In the Department of Horticulture, the manner in which various cultural practices affect plant growth is being studied, both in the field and under carefully-controlled conditions. Investigations are being made of the water-relationships of plants grown under glass, with particular reference to tomatoes (a relatively long-term crop) and lettuces (a short-term crop) grown under a range of different water-regimes. The results of this work have shown that the frequency with which water is applied to some crops may be even more important than the total amount dispensed, suggesting that careful control of irrigation may not only increase crop yields but also economize in the use of water. This conclusion may have wide implications in crops and areas where availability of irrigation water is a limiting factor. The processes involved in the regeneration of plants from leaves, portions of leaves, and roots are also being studied, with particular reference to the effects of daylength and temperature on the habit of growth of shoots from root buds. Detailed work is in progress on the factors which affect the emergence and establishment of vegetable seedlings in the field and under laboratory conditions. The check to growth caused by transplanting seedlings and young plants is often serious, and studies are being made of the effects of transplanting damage, levels of soil moisture, temperature and light intensity on the recovery of young plants from the transplanting check.

A preliminary investigation in the Crop Husbandry section has shown there to be very great differences in the yield from single tubers planted side by side in the same row, and further studies are under way to investigate further the source of this variation. The results have been published of a detailed study of the growth of the potato plant by the Agricultural Zoology section in connection with their studies of aphid migration. For several years the School has been a centre for work on potatoes and an extensive series of plots are maintained on behalf of the Ministry of Agriculture, both for testing new introductions and for training inspectors of potatoes for seed production. Plots are also maintained for the Agricultural Research Council's team that is investigating potato storage.

In recent years considerable interest has been aroused in agricultural circles both in England and overseas on the role of certain metallic elements that are required by plants in very small amounts.

With the erection of new glasshouses and a sand-washing plant, investigations have now been started in the Agricultural Chemistry section of the interactions of certain of these elements in the butrition of some pasture legumes. The legumes selected for this work are lucerne (*Medicago sativa* L.) subterranean clover (*Trifolium subterraneum* L.), white clover (*T.repens* L.) and lupin (*Lupinus luteus* L.), which represent a series of crops, of which the optimum growth range varies from acid to alkaline conditions. Studies are also in progress of the effects of acidity on the development of the nodule organisms concerned.

Pasture problems are also under investigation in the Crop Husbandry section, and an investigation has been made of the interaction of nitrogenous fertiliser and white clover in swards cut for conservation. Studies have also been made of the technique of measuring the quantities of herbage consumed by the grazing animal, and the relationship between production measured in various ways.

One of the factors considerably reducing the yield of arable crops is the effect of weeds. Control of the weed population has been achieved traditionally by cultivation, but a large burden of dormant seeds not uncommonly requires these cultivations to be done far too frequently. Among the investigations carried out in Agricultural Botany, consequently, attention has been given to certain weed problems. Many of the difficulties in the control of charlock (*Sinapis arvensis* L.) arise from the small proportion of seeds produced which germinate in the following season, this dormancy can only be slightly influenced by subjecting the seeds to long periods at low temperatures and would appear to be due to an inhibiting substance which is continually produced by the seeds when moist. Evidence suggests that this substance is produced from two separate precursors, one of which is present in the seed coat and one in the embryo. Removal of the seed coat allows full germination and an inhibiting diffusate can be obtained from whole seeds and from embryos and seed coats together but not from the seed coats alone. Investigations of this system and of quantitative changes under field conditions are continuing. Species of *Polygonum*, especially wireweed or knotgrass are also important weeds. An analysis of the factors which influence the germination and growth of these species and of barley has been commenced in order to ascertain more clearly the principles of plant competition. The differential behaviour of the chief commercial varieties of oats to spraying with the weedicides, 2 : 4 dichlorophenoxyacetic acid and 4 : chloro : 2 methylphenoxyacetic acid, is also being studied.

It has been found that leguminous crops when grown in boron-deficient soils have markedly reduced seed yields. This will occur, first, because of decreased vegetative growth and flower production; and secondly because of the failure of the individual flower to set seed. The causes of failure in individual flowers is expected to be due to chromosomal aberrations occurring during gamete formation and to inadequate nutrition of the pollen tubes produced by the male gametes. An investigation is therefore being made in red clover (*Trifolium pratense* L.) and field bean (*Vicia faba* L.) of the influence of level of boron supply on vegetative growth and on the rate of mitotic cell division. The level of boron supply needed to incapacitate individual gametes for either of the two reasons mentioned is also being determined.

The association of fungi with the roots of certain plants without disease symptoms is well-known. A survey of these mycorrhizae on the roots of grasses and cereals has been made and one particular fungus (a vesicular-arbuscular type, probably of the genus *Rhizophagus*) has been found to be very widespread, occurring on a wide range of grasses and cereals growing under widely different conditions. Although this fungus is almost universally present, the intensity of root infection varies under different conditions and would appear to be diminished under conditions which favour high microbiological activity. It is not yet known whether this association is beneficial, detrimental or merely incidental, but, under certain conditions, the fungus could provide a channel for transferring nutrients from the soil to the root system.

Serious losses of grass seed often result from Choke diseases, caused by *Epichloe typhina* Fr. Investigations have been commenced on the method of infection and on the relation of the parasite to the growth of the host, particularly as to the nature of the extensive fructification of the fungus which occurs only as the inflorescence of the grass is developing.

Factors affecting animal growth and production.

Investigations have been made in the Animal Husbandry section into the relationship of nutrition to fertility and growth in farm and laboratory animals. In particular attention has been focussed on the effect of incipient vitamin A deficiency on reproduction and growth in rabbits and in sheep and on the effect of low levels of vitamin A on the growth of calves. The work with sheep is being done in co-operation with the Ministry of Agriculture Veterinary Investigation Centre.

Studies are also being made of the influence of thyroid and oestrogenic hormones on the growth and carcase quality of lambs, whilst in the Agricultural Chemistry section the influence of thyroid hormone on the copper metabolism of the sheep is being investigated. The use of hormones in reproduction is also being investigated. Co-operative studies with the Unit of Animal Reproduction at Cambridge are being made of the use of Pregnant Mares' Serum to induce twinning in beef herds, and into the use of ovarian hormones to treat genital infection in cattle and rabbits.

Research on environmental factors in the growth rate of pigs has been continuing for some time, and the results are reviewed in detail later in this report.

A study has been made of the comparative anatomy of the digestive tract of poultry and geese, from which it has been found that there are marked differences in the rate of development of different parts of the intestine, and there is some evidence that the development may be affected by the character of the food consumed.

Entomological studies.

One of the bases of research work is to know precisely what is being dealt with, and the Agricultural Zoology section continues to pay considerable attention to taxonomic studies. One major problem is a systematic investigation of certain Orthoptera (locusts and grasshoppers), especially *Chrotogonus*, which is an African and Asiatic genus containing certain injurious forms known as toad-locusts or surface grasshoppers. It has been possible to give some order to the formerly confused state of the systematics. Two other injurious genera have also received attention, namely the South Indian wingless grasshoppers (*Orthacris* spp.) and the migratory longhorns (*Homorocoryphus* spp.). Work is also in progress on the bionomics of some species of cutworm, in particular *Triphaena pronuba*, a common pest of horticultural plants about which surprisingly little is known. Taxonomic studies are also being made of the Black Aphis complex.

The importance of aphids in the spread of the virus diseases of potatoes is already well-known. Studies of the aphid populations of the potato crop have indicated that both aphid colonization and the progress of infestation are closely related to plant growth.

Attempts have been made to follow the movements of individual winged aphids within the crop by making them radio-active, either by prior feeding on radio-active potato plants or by spotting with radio-active paint. The former method was unsatisfactory as the

insects did not become sufficiently radio-active, but the painting method, although very tedious, was more successful. The majority of aphids released were shown to fly to a distance outside a 40 foot radius, but most of those which did not do so were found within 10 feet of the point of release.

Microbiological studies.

In microbiology, no less than in entomology, there is a continuous need for further work on the classification of genera of agricultural interest, and in particular to variations in their bio-chemical characteristics.

Work is continuing on the classification of the gram-negative bacteria isolated from grasses and more accurate methods have been devised for the recognition of the fermentation products of the organisms of the coliform group involved.

Work on the anti-bacterial mechanism of phenanthridine compounds has proceeded further, and the re-assessment of 140 of these compounds has indicated that the qualities for anti-bacterial activity are the same as for anti-trypanosome activity. An antagonism has also been noted between *Serratia marcescens* (or *Chromobacrerium prodigiosum*) and *Staphylococcus aureus*, one of the causes of mastitis, which is of interest because if the inhibitory agant liberated can be developed it may be valuable against Staph. aureus in view of the resistance of the latter organism to penicillin.

The studies of the production of fats by yeasts are continuing, and have been extended to allow an investigation of fat production by moulds, using whey as the raw material.

Farm Management Studies.

The major investigation in this field has been the collection by the Department of Agricultural Economics of information about financial results of farms in the East Midlands for the Farm Management Survey, and the classisication of the farms according to the dominant feature of production has been published.

Costing of several agricultural products has also been carried out, and particular attention has been paid to the cost of milk production by the detailed analysis of the costs of one constant group of farms over a five-year period.

One of the problems besetting all attempts at the costing of agricultural products is the variation that exists from one farm to

another in the factors affecting costs. This variation can be subjected to statistical treatment, and an analysis of variance of the data is being carried out in an attempt to calculate empirical production functions from the farm accounts available.

Some analysis has been made of the special problems of farms in the Peak District of Derbyshire, in co-operation with the Agricultural Land Service and the National Agricultural Advisory Service.

THE SECOND EASTER SCHOOL IN AGRICULTURAL SCIENCE APRIL 1st—7th, 1955.

The Second Easter School in Agricultural Science was devoted to soil zoology. Its purpose was to provide a forum for the exchange of ideas and information, and in addition to specialist papers, a course of demonstrations and practical classes was provided for about 35 graduates from related fields on the methods and techniques employed in the study of soil animals. Membership was limited to 70, which included distinguished workers in soil zoology and pedology from several European countries.

The opening paper by Professor W. Kühnelt (University of Vienna) on the study of soil animals, and the subsequent paper by Dr. P. W. Murphy (Rothamsted) on the fauna of forest soils, served not only as an introduction to soil zoology but also emphasised the need for the closer co-operation between soil biological and pedological research.

Methods for the extraction and quantitative estimation of the soil fauna were dealt with in the papers of Dr. F. S. J. Hollick (Cambridge) and Mr. A. Macfadyen (Oxford), and in the demonstration of Dr. F. Raw's flotation extraction process for soil micro-arthropods by his colleagues Mr. J. M. Dobson and Mr. J. W. Stephenson (Rothamsted). The recent improvements in the extraction and sampling techniques have given a considerable impetus to investigations of the distribution of animals in the soil. This was illustrated by the studies of Mr. Niels Haarlöv (Copenhagen) in his paper on vertical distribution of mites and collembola in relation to soil structure, by Dr. C. Overgaard Nielsen (Femmöller, Denmark) in his survey of a year's results for the extraction of soil-inhabiting enchytraeid worms, and by Mr. D. H. Murphy (Durham) in his account of a study of ecological succession in collembolan populations of moorland soils.

The distribution of different groups of animals in relation to soil type and soil stratum was discussed by Mr. J. G. Blower (Manchester) on myriapods and centipedes, and by Dr. W. J. McL. Guild (Edinburgh) and Dr. J. E. Satchell (Nature Conservancy), each of whom made a contribution on some aspects of earthworm biology. Professor W. L. Kubiena (Madrid) showed coloured slides of thin soil sections which illustrated the effects of animal activity in the establishment of humus forms. Professor W. Tischler (Christian-Albrechts University, Kiel) described the characteristic fauna of different types of agricultural land and also discussed the effect of ploughing, harrowing, etc. on the population density of certain groups of soil animals.

Applied aspects of soil zoology were dealt with by Mr. E. B. Brown (N.A.A.S., Cambridge) in his paper on some current British soil pest problems, by Mr. J. G. Sheals (Glasgow) who discussed the effects of DDT and BHC on some soil collembola and acarina, and by Mr. F. G. W. Jones (Cambridge) who dealt with the difficulties of estimating the numbers and viability of cyst-forming nematodes in the soil.

Other papers included those of Dr. G. O. Evans (British Museum) who outlined the problems encountered in the identification of terrestrial mites; the general biology of soil-inhabiting nematodes was covered by Dr. B. G. Peters (Rothamsted); a paper on termites and the soil by Mr. W. V. Harris (Commonwealth Institute, London) was delivered by Mr. W. A. Sands (Commonwealth Institute). Two papers given by Drs. C. L. Duddington and Mary Peach (The Polytechnic, London) dealt with fungi predaceous on soil nematodes and protozoa.

Practical demonstrations in the laboratory and in the field were devoted to various techniques for soil sampling for nematodes and micro-arthropods, extraction methods, soil sectioning, and the mounting, preservation and identification of various groups of soil animals. There were also static exhibitions of water relations of soil myriapods (Mr. J. G. Blower), the rearing of symphylids and collembolans (Mr. C. A. T. Edwards, N.A.A.S., Bristol), the effect of insecticides on soil fauna (Mr. Sheals), zoophagous fungi (Drs. Duddington and Peach), and two pieces of apparatus for the study of metabolism in soil animals (Mr. Macfadyen). Many other items of interest were also on display.

The entire proceedings of the Easter School, including the techniques demonstrated, the discussions, and a number of papers read by title only, edited by the organising secretary, Mr. D. K. McE. Kevan, were published by Messrs. Butterworths in November under the title "Soil Zoology".

STUDIES ON PODZOL SOILS

D. V. Crawford

Acid soils of the podzolic group are found in Britain in many areas of heath or moorland, and also in other locations where they have been modified by cultivation. In a typical profile, peat overlies a bleached horizon (the A-horizon) from which iron and aluminium oxides have been leached, and deposited in part in a lower horizon. This zone of accumulation (the B-horizon) may in some cases become hard and compact, restricting water movement and root penetration and thus reducing the value of the soil for agriculture.

In many parts of this country the climate does not decisively favour their formation and the balance between podzolic soils and the more fertile brown earths is controlled by vegetation and usage. Empirical evidence exists which suggests that afforestation with uniform stands of conifers commonly induces podzolization and many foresters would advise mixed plantations containing a proportion of deciduous trees to maintain the fertility of the soil. Since, however areas are known where podzols appear to have formed under deciduous trees, it seems likely that before measures to control this form of soil deterioration can be widely applicable, a better under standing of the mechanism of the podzolization process is required.

Several theories have been advanced in the past to explain this type of soil formation. Mattson[1] has suggested that the products of weathering move separately through the profile, the inorganic colloids being stabilized by organic matter, and are subsequently flocculated in the B-horizon. He has, however, given little attention to biological aspects of the problem. Trefor Jones and Wilcox[2] demonstrated the efficiency of simple organic acids as solvents for sesquioxides and the possibility of subsequent precipitation by supposedly basic salt formation. Some suitable organic acids do occur in plants and others may be formed by micro-organisms, but against this, there is no conclusive evidence for the existence of such organic acids in the percolating soil solution, in spite of various attempts to isolate them. Their existence may be so transient owing to microbiological breakdown that new methods of detection may have to be devised, though Sallans and his co-workers[3] did obtain acetic acid from the raw humus of a podzol, and Norman[4] reported the occurrence of uronic acids and suggested that these may be the operative carriers.

More recently, Bloomfield[5] has shown that certain aqueous leaf extracts can mobilize iron and aluminium from a mixed precipitate of hydroxides; this property is strongly developed in Scots

pine and the New Zealand 'kauri'. As a result he dismisses the role of peat as of little importance in comparison with influence of extractives from freshly-fallen leaves. In common with many other workers in this field he neglects the activities of micro-organisms.

Studies of microbiological activities in podzol profiles have been concerned with the possible action of those autotrophic organisms of the family Chlamydobacteriaceae capable of oxidising ferrous iron to ferric iron ; and with the distribution in the profile of the cellulose decomposing, the nitrifying, and the urea-decomposing organisms. Little attention has so far been given to the specific processes of iron and aluminium mobilization and deposition. It appeared to the author that microbiological processes are worthy of more attention than they have been given, and various lines of work have been undertaken. It has been shown that in a sterile peat extract an equilibrium between iron and organic matter was attained which was sharply altered by inoculating with soil organisms, the level of both iron and organic matter being changed. One unsolved difficulty in this work is that it is not possible to suppress all biological activity without interfering with soluble or colloidal materials ; organic disinfectants such as chlorbutol bring into solution more organic matter, while heavy metal salts such as mercuric chloride are likely to cause flocculation of the colloidal material.

A search* was made for organisms in podzol profiles which might play a part in depositing iron. Special attention was given to the Chlamydobacteriaceae but without obtaining any evidence that they played a a significant part. It was found that some organisms were capable of depositing iron hydroxide from an iron ammonium citrate medium by utilizing the organic acid, and that these represented a larger proportion of the total count in the B-horizons than elsewhere. Identification of the organisms capable of precipitating iron under these conditions showed that in the lower horizons Corynebacteria predominated and could utilize a wide variety of organic acids as carbon sources.

As a first stage in the investigation of the mobilization of iron and aluminium, quantitative studies have been made of the amounts of iron and organic matter in incubated extracts prepared under aerobic and anaerobic conditions, using humic materials of different origin. Marked differences have been observed, anaerobic conditions usually giving rise to more soluble iron, often in a form apparantly stable to aerial oxidation. Qualitative tests for iron with *dd'*-dipyridyl have been positive but there are theoretical objections to stating that therefore

*In co-operation with Dr. M. E. Chislett, now of Univ. of Reading.

the iron is present in the ferrous form. It is intended to extend these mobilization studies to include a wider range of trace elements, and also aluminium, since the latter does not undergo the changes of valency which with iron and manganese predispose them to movement under anaerobic conditions.

The reversal of the process results in the formation of the B-horizon by the immobilization of the iron and aluminium and some of the organic matter. This is equally important, and to study it a series of peat extracts have been percolated slowly through various podzol horizons and the degree of sorption measured; the results are quite compatible with the development of a podzol profile. There is, however, the interesting point concerning the renewal of sorptive capacity of the B-horizon; it is likely that the B-horizon would soon become saturated unless the sesquioxide-organic materials deposited there are altered in some way. In view of the micro-biological evidence previously obtained the hypothesis is being tested that the micro-flora of the B-horizon are the means by which the sorptive capacity is renewed.

It should be stressed, however, that there may be more than one mechanism operating and that under varying conditions the relative importance of different processes may alter.

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THE USE OF CONTROLLED WATER-REGIMES IN EXPERIMENTAL WORK

J. P. Hudson

Introduction.

Interest in the question of irrigation is growing, since there is evidence that the yield of many crop plants may be reduced by lack of water during the summer months, even in relatively wet years. To find out the effects of water on growth it is necessary to use some method of controlling the moisture status of the soil in order that the behaviour of plants may be studied under a variety of pre-determined moisture conditions.

The ideal approach would be to grow plants in soils which were maintained throughout a period at various constant moisture tensions, but that is impossible to achieve in practice. In any given mass of soil, in which roots are simultaneously absorbing moisture and extending in length, moisture is likely to be removed from the soil immediately around each root more quickly than it can be replaced by moisture moving towards that root from the surrounding soil, whilst water cannot of course, be re-introduced from outside the system into the neighbourhood of each root at exactly the same rate at which it is being removed.

Although it may be impossible to maintain the moisture throughout a mass of soil at any particular moisture tension it is quite possible (a) to bring the soil more or less uniformly to a pre-determined moisture status at the beginning of an experiment, and (b) to maintain different, definable and reproduceable water-regimes throughout the experiment, in which soil moisture is allowed to fluctuate only between pre-determined limits. The Department of Horticulture is interested in both these aspects and has developed techniques, based on the concept of water-regimes, for studying the moisture relationships of plants.

Bringing soil to a uniform moisture status.

Field capacity is by far the easiest uniform moisture status to attain in practice in most types of soil, since it can be achieved by applying an excess of water to the soil in a well-drained container or bed and waiting until gravity water has virtually ceased to drain out. This may take from a few hours to a few days but can be checked by observation. Lysimeters, consisting of large containers from which drainage water can be collected, provide a useful means of checking

the flow of water from beds of soil, and eight lysimeters, of simple construction, are in use in the Department of Horticulture for that purpose.

Where it is required to bring soil to a uniform moisture status drier than field capacity, this can conveniently be done for small quantities of soil by mixing intimately a measured volume of air-dried soil with a measured quantity of soil at field capacity, and storing the mixture for two or three days in a closed container or under a damp cover. This method has been used successfully in preparing soils of uniform moisture status for work on the germination of seeds in containers.

Methods of maintaining experimental water-regimes.

There are many different approaches to the problem of maintaining definable and reproduceable water-regimes but the following have been used successfully in the Department. In all the methods soil moisture content is allowed to fluctuate only between two pre-determined conditions, one being field capacity and the other a measurable stage in the drying cycle. The regimes have been based on the use of Gallenkamp soil moisture tensiometers for measuring moisture tension, and the work has been done in glasshouses where rain can be prevented from falling on the beds[1] [4].

Tomatoes and lettuces in beds of soil.

Plants have been grown in brick-walled beds containing 30 inches of soil and sub-soil, and have been given four different water-regimes replicated six times in randomized block layouts. In each treatment the following sequence has been followed :—

First, the bed has been allowed to dry until a key tensiometer at a standard depth (6in. and 3in. for tomatoes and lettuce respectively) has indicated a pre-determined tension. The approximate water deficit of the bed has then been calculated, based on tensions recorded at various depths and the known moisture characteristics of the soil.

Next, just sufficient water has been applied to each bed to replace the calculated water deficit, re-wetting all the soil to field capacity but without any passage of water through the soil to drainage, thus avoiding leaching of nutrients.

Finally, the calculation of water deficit has been checked by applying a slight surplus of water to the lysimeters and measuring the amount of effluent (gravity water), which should be similar to the amount of surplus water applied.

Lettuces in glazed drainpipes.

Single lettuce plants have been grown in glazed earthenware drainpipes, 3ft. high and 8in. diameter, under water-regimes controlled as above. This method has proved useful in the study of root systems since the pipe can be broken and entire root systems recovered for examination.

Ornamental species in unglazed plant pots.

A method of maintaining definable water-regimes in unglazed earthenware plant pots has been used in the study of the water-relationships of several species of ornamental plants. Although tensiometers are too expensive and bulky to be used in each pot, four empirical criteria, each of which can be correlated fairly closely with a particular moisture tension, have been used to determine the timing of irrigation, thus enabling four different water-regimes to be followed.

Results of experiments on tomatoes and lettuces.

The techniques described above offer practical methods of studying the moisture relationships of any crop plant provided it can be grown in containers or beds under some form of coverage which will prevent rain from falling on the soil.

The methods are proving useful in the study of the effects of different water-regimes on growth and particularly to determine the latest stage in the drying cycle at which water must be applied to prevent growth from being checked by lack of moisture. The results which have been obtained are of considerable practical interest. It has been shown, for instance, that the growth and yield of tomato plants is seriously checked if the soil is allowed to dry out much below field capacity before being watered, and the best principle in watering this crop seems to be to apply water frequently, even daily, during the main growing season but without waterlogging the bed[3] [5].

On the other hand, with lettuce there seems to be no advantage in frequent watering[2]. Indeed, provided the soil is deep enough and is thoroughly wetted (to field capacity) before the crop is planted, lettuces have grown equally well in repeated experiments whether watered or not. The explanation of this behaviour appears to lie in the nature of the crop, which matures rapidly and in which roots are still growing into the deeper levels of soil up to the time the crop is cut. These deeper roots appear able to obtain sufficient moisture

to sustain full growth of the lettuce plants even though the surface layers of soil have been depleted of most of the readily-available moisture.

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STUDIES OF BASIC CULTURAL OPERATIONS

1. SEED SOWING AND TRANSPLANTING

by Winifred M. Dullforce and W. Heydecker*

A variety of basic cultural operations are involved in the production of a crop, and the way in which these are carried out may have a profound effect upon growth and yield of the plants concerned. The majority of outdoor crops grown in Britain are raised from seed sown in the field, where successful germination is the first essential step towards producing a crop. Many horticultural crop plants are subsequently transplanted at least once, and this operation is a further critical event in the life history of the plants.

Research work is in progress in the Department of Horticulture to study the reasons for the variations which are often experienced in the germination of field crops and to find means of eliminating such variations ; and to explain the nature of the "transplanting check" and suggest ways of aiding the recovery of transplanted plants or avoiding the check altogether.

*Mr. Heydecker's work is concerned with the factors affecting germination whilst Miss Dullforce is studying the effect of the transplanting check.

Germination of vegetable seeds in the field.

Several separate factors are likely to influence field germination, but although they are separate, their effects are always inter-related. Most seeds will germinate satisfactorily under quite a wide range of conditions but it would be an advantage to define this range for each species and to find how the optimal range can be provided, economically, in practice. It has frequently been shown elsewhere, and has been confirmed in the present work, that a high proportion of germination failures are due to attacks by soil fungi on the seed or germinating seedling. Fungicidal seed dressings have been shown to reduce the severity of such attacks, especially under extremely wet or dry conditions. However, the work in progress is chiefly concerned with factors which affect emergence of the seedlings from the soil by influencing their growth rate. Given healthy seed, a well-drained soil, and soil temperatures suitable for germination, soil moisture may be a limiting factor. The drier the soil, the slower the rate of germination. Lettuce seed has proved especially susceptible to drought conditions, whilst carrot and onion appeared to be less so. Cabbage seed germinated at a distinctly lower soil moisture content than any of the other three species. On the other hand carrot and onion seeds were better able to survive temporary drought conditions in the soil than were cabbage and lettuce seeds.

In all instances, the speed and percentage of germination have both been greatest at or just below field capacity (see page 30) provided the soil did not become re-wetted above field capacity subsequent to sowing. In land which was flooded after sowing, either by heavy rain or irrigation, germination appeared to depend largely on the structure and texture of the soil. In experiments where soil particles were uniformly pulverised to pass through a $\frac{1}{16}$ inch riddle, germination after soaking was poor even though the soil was naturally well-structured. More disastrous results were obtained when a close-textured soil was flooded, even though all the portion that passed through a $\frac{1}{2}$ inch riddle was originally omitted. In the latter soil the process of flooding apparently closed all the pores of the soil and the seed failed to germinate at all until the soil had partially dried out. This took some weeks, by which time the capacity of the seed to germinate was vastly reduced. Of the species tested, cabbage appeared to be the most, and beetroot the least, susceptible to excessively wet conditions.

Results of experiments indicate that physical pressure upon the seeds is unlikely to be the factor responsible for the failure of seedlings to emerge under the circumstances described above. A more

probable reason for failure is that germination is depressed by the composition of the soil atmosphere immediately surrounding the seed. Whilst actual measurement of the composition of soil air presents considerable difficulties, laboratory experiments have shown that the germination of all the seeds so far investigated is suppressed by high carbon dioxide and/or low oxygen contents; furthermore, certain combinations of the two gasses have been shown to cause severe injury to the radicle emerging from the seed.

It is important to avoid using too fine a seedbed and, in addition, to sow seeds at the correct depth. By sowing at a depth where the soil is unlikely to dry out too rapidly during a rainless period but where sufficient oxygen can penetrate soon after a downpour of rain, satisfactory seedling emergence can be expected. Shallower or greater depths of sowing sometimes produce satisfactory stands, and under ideal conditions of structure and moisture sowing depth may matter little within wide limits; but in more critical conditions seeds sown at the correct depth have been found to grow with fewer failures. A sowing depth of $\frac{3}{4} \pm \frac{1}{4}$ inch (without subsequent rolling of the soil) has been found to be most satisfactory for carrot, onion, beetroot, lettuce and cabbage for the sandy loam at Sutton Bonington. Under laboratory conditions the same depth also proved safest for sowing in a clay loam, producing the maximum stands of seedlings.

Transplanting seedlings and young plants.

Transplanting involves disturbance in which the root or shoot is often injured and it may also involve removal of a plant to a new environment with different light, temperature and moisture conditions. Work has been carried out to define the extent of the transplanting check in plants such as lettuce, tomato, cauliflower and cabbage which are normally transplanted either once or twice.

Pricking-out.

Various factors affecting the recovery of young lettuce seedlings, raised and pricked-out in heated glasshouses, have been studied. No significant differences in growth were obtained when seedlings which were pricked out with normal care at 3 or 14 days after germination (under winter conditions) were compared with undisturbed seedlings thinned out to a comparable spacing in wooden seedboxes of 14 x $8\frac{1}{2}$ x $2\frac{1}{2}$ inch dimensions.

Various degrees of injury were inflicted on the roots and/or shoots of lettuce seedlings during pricking out, including bruising one cotyledon, removal of one or both cotyledons, and removal of

part or practically the whole of the primary root. The growth rate of the shoot was reduced according to the degree of injury inflicted, but unless the injury was so extreme as to result in death of the plant (e.g. where both cotyledons were removed) the check to growth was only temporary, since normal growth rates were later resumed. Even some of the severely-injured plants survived and ultimately recovered their normal growth rate. Similar results were obtained with tomato seedlings.

When seedlings are not disturbed they must, of necessity, remain in the compost used for germination, but when pricked out fresh compost (often richer in nutrients) is used. It was found that when pricking out was done 14 days from the opening of the cotyledons the use of fresh compost for lettuce seedlings, even though it was of the same type as used for seed sowing (JIP 1), gave significantly increased weight by the time the seedlings were ready for planting out, i.e. when approximately 2 inches high. Where seedlings are pricked out and planted out earlier the effect of the fresh compost might not be shown.

The type and amount of compost used for pricking out lettuce seedlings was also studied. The effects of three different amounts of three types of compost (JIS, JIP 1 and JIP 2) were compared. No advantage was derived from giving each plant more than the usual quantity of compost ($3\frac{1}{2}$ ozs.) unless the nutrient status was low (JIS) or the seedlings remained in the boxes for longer than the normal period (i.e. until the seedlings were more than 2 inches high). Growth was slightly reduced when the amount of compost was reduced from $3\frac{1}{2}$ to 3 oz. per plant. No advantage was derived from using JIP 2 as compared with JIP 1.

Experiments comparing the use of soil blocks, clay pots and boxes suggested that the container used for pricking out may influence growth up to the time of planting out, but for three crops tested (lettuce, cauliflower and cabbage) there were no significant differences, providing the quantity of soil and plant spacing were uniform for all types of container. For tomatoes the box was apparently a less satisfactory container than soil blocks or clay pots, since growth was significantly reduced even when the spacing of plants and the amount of compost per plant were comparable. It should be pointed out, however, that for all four crops the use of boxes as opposed to blocks or pots may have an important bearing on the amount of root injury incurred during planting out.

The similarity between the appearance and size or weight of aerial parts of plants grown in soil blocks and clay pots was striking

for all four species and it is suggested that differences obtained by other investigators may have been due mainly to the varying quantities of compost supplied in the different types of container.

The effects of two different spacings in boxes were also compared. For tomatoes, cauliflower and cabbage spacings were $2\frac{1}{4}''$ x $2\frac{1}{4}''$ (24 plants per box) and $4\frac{1}{2}''$ x $4\frac{1}{2}''$ (6 plants per box) ; for lettuce $1\frac{3}{4}''$ x $1\frac{1}{2}''$ (48 plants per box) and 3" x 3" (12 plants per box). The closer spacing was detrimental to the growth of tomato plants, which became drawn and reduced in weight by nearly 50% whereas the size of cauliflower and cabbage plants, as expressed by length of leaf, was only slightly reduced. Closer spacing of lettuce seedlings resulted in larger, thinner textured plants, but dry weight was not reduced.

Planting out.

Comparisons have been made between lettuce plants transplanted twice (i e. pricked out at the cotyledon stage, then later transplanted from soil blocks, clay pots and boxes) and plants pricked out direct into their final positions in a cold glasshouse, thus eliminating the second disturbance. Transplanting from clay pots or soil blocks had practically no effect on the growth rate as compared with undisturbed plants, but removal of plants from boxes involved reduction of the root system and resulted in a check to growth which was much greater where plants had been closely spaced in the boxes. Once again, however, it was demonstrated that the check was only temporary since normal growth rates were later resumed. Transplanting involving injury to the root system had a delaying effect on maturity. Similar effects were indicated for tomatoes grown in a cold glasshouse and for cauliflower and cabbage plants grown out-of-doors ; with each crop, methods of transplanting which involved considerable reduction of the root system checked growth but had no significant effect on ultimate yields, although the dates of harvest were delayed.

Conclusions.

The evidence strongly suggests that where transplanting can be carried out without injury, either by pricking out early at the cotyledon stage or by the use of containers such as soil blocks or clay pots where roots are not disturbed on planting out, growth can continue virtually unchecked ; but methods which involve reduction of the root or shoot are likely to result in a temporary reduction in the rate of growth with a consequent delay in cropping.

AGRONOMIC FACTORS AFFECTING YIELD OF POTATOES

J. D. Ivins and V. J. Montague*

In 1953 a preliminary survey of the potato crops on the University Farm was made with a view to investigating the variations in yield attained by different plants in the crop. The yields of individual plants in a healthy and apparently uniform crop were found to vary over a very wide range, from **16 per cent to 270 per cent** of the mean yield per plant. Allowing for variable factors such as soil conditions it was felt that by attention to detail, it should be possible to attain a more uniform and higher yielding crop. With this in view an attempt was made to trace the source of some of the variations between individual plants, and attention was mainly given to the variety King Edward, the most popular good quality variety grown in England.

In the spring of 1954, experimental plots were laid down to estimate the effects of spacing, seed size, and the possible existence of high and low yielding strains within the variety. Records of the time of emergence and number of stems were obtained, together with the size, weight and number of 'ware' and 'seed' size tubers from individual plants.

It has been found that planting sets wider than 12 inches apart in 28 inch drills lowered total yield per acre. The yield of ware-sized produce (over $2\frac{1}{4}$ inch riddle), however, was virtually unaffected by spacing sets up to 32 inches apart[1].

A general association between seed size, stem number and tuber number was observed. As might be expected, large seed tended to give rise to a greater number of stems per plant which in turn gave rise to greater tuber numbers per plant. There was a strong indication that early emergence of the crop is advantageous. Plants emerging early gave higher total yields and higher yields of ware than those emerging later. In one experiment seed was desprouted prior to planting, as might happen with careless handling of sprouted seed at planting time, and the yields obtained were compared with those from intact sprouted seed. Desprouting led to irregular emergence and while there was no significant difference in the total yields obtained from desprouted and intact seed the former gave 2 tons per acre less ware (over $2\frac{1}{4}$ inch) than the latter. These studies are continuing.

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Samples of seed collected from high, medium, and low yielding plants on the crop have been compared but so far there is no evidence of hereditary differences in yielding potential between individual plants in a crop.

The 1955 programme of trials was designed to obtain further evidence on the factors already investigated and to study certain additional aspects of the problem. The results confirmed the desirability of wider spacing with the variety King Edward, but with Majestic wider spacing lead to a high proportion of coarse and cracked tubers. The depth of planting was found to have a great effect on tubers numbers, generally the more shallow plantings gave the highest figures. Sprouted seed outyielded non-sprouted by 33% in 1955 while the effects of 'weathered' and 'acclimatised' seed were not reflected in differences of yield. In a small scale trial tubers planted with the rose-end downwards yielded between 14% and 19% less than those planted upright. This result was associated with delayed emergence of those plants arising from the tubers planted rose-end downwards.

In view of the apparent association between yield of the potato crop and summer rainfall[2] an attempt was made in 1955 to determine the effect of irrigation on the growth and development of the potato plant and the quality of produce. In this preliminary trial in an exceptionally dry summer, ware (over $1\frac{3}{4}$ inch) yields were exactly doubled by irrigation and no deterioration in cooking quality could be ascertained.

From the results obtained so far, it is clear that a full understanding of all factors which may affect plant growth is required if one is to give attention to those details of cultivation which are responsible for maximum yields.

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THE POTATO VARIETY PLOTS

N. McDermott

Fifteen years ago the Ministry of Agriculture and Fisheries made arrangements with the former Midland Agricultural College for the annual planting of potato plots. The establishment of these plots at a more central locality followed on the Ministry's decision to discontinue the field testing of new varieties of potatoes previously carried out at the Potato Testing Station, Ormskirk, Lancashire, which, since 1920, had successfully carried out the work in ground infected with Wart Disease.

Instructional Plots.

The primary object of the potato plots at the School of Agriculture is to provide material for the training of the National Agricultural Advisory Service Officers, and to this end a reference collection is planted with as many varieties as it is possible to obtain in the United Kingdom. This year, the number of **named** varieties planted will be about 200, and this museum includes those grown on a commercial scale ; varieties not grown extensively in England and Wales which are of special interest to small growers and gardeners ; old and obscure kinds, some of which are over 130 years old and others which have disappeared from the trade but which are valuable in checking the distinctness of entries in the official Registration Trials, for no variety is registered unless it has been proved to be distinct from existing kinds. Also included in the reference collection are new, approved, immune varieties and these plots serve a two-fold purpose—they provide material for the study of growth characters which officers will ultimately be called upon to examine, and they also bring their 'commercial worth' to the notice of growers who are thus able to obtain first-hand information on their performance.

Another series of plots includes a collection of 'rogues', i.e., varieties found as mixtures, which are used for training in the examination for purity. To help in the classification and diagnosis of virus diseases and variations, plots of suitably-affected material are provided, such as plants affected with mild mosaic, severe mosaic and leaf roll, wildings, bolters, feathery wildings, and other undesirable variations.

Trials of New Seedlings.

Under present arrangements, a seedling is tested in the official trials in England (Nottingham University School of Agriculture), Scotland and Northern Ireland simultaneously, and if it proves to be

a distinct immune variety it is added to the approved list of varieties immune from Wart Disease, and any of outstanding promise are registered after two or three, or even four years test. It should be pointed out that distinctness of type and immunity from Wart Disease, though important, do not comprise the hall-mark of perfection in a variety. During the time a seedling is under test, a full botanical description is compiled together with all possible information on its performance and various qualities and weaknesses.

Since the inception of potato trials in this country, thousands of varieties have been raised and tested, but relatively few have merited the outlay which would be involved in their introduction to industry. For a variety to become popular it must embody those qualities preferred by the grower, namely cropping power, freedom from second-growth, immunity or relative immunity from diseases, good-keeping quality and ease of culture. The variety must stimulate public demand by its colour, shape, size and eating quality, though the preference of the consumer varies amazingly even within this country.

One great advantage being reaped from past work is that the naming of varieties is now well in hand. Potato synonyms—or in other words, named varieties that have been found to be 'identical with other varieties'—have disappeared, whereas they formed 72% of the total numbers in 1920.

Certified Seed Stocks.

These plots are planted with seed samples from crops certified under the Potato Seed Certification Scheme from Scotland, Northern Ireland, England and Wales grown side by side and cover about two acres annually. The stocks with the various grades of certificates are always critically appraised by growers visiting the trial field during the summer, and such indefinable qualities as vigour, uniformity and type are often found to play as big a part in comparison as purity and freedom from disease. This section also serves as a useful guide as to the merits of certain parts of England and Wales as suitable seed-growing areas.

Samples from crops rejected in the previous year are also obtained and planted up as a "problem corner", providing admirable material for promoting discussions during the training of the N.A.A.S. officers.

Educational Work.

Three separate courses are arranged annually for the N.A.A.S. personnel, namely a short refresher course for those engaged on field

inspection work under the Potato Seed Certification Scheme; an instruction course for trainees; and an advisory course for officers who are desired to keep up-to-date on potato varieties and problems. These courses entail much detailed field study during the first fortnight of July each year.

Potato merchants are as fully alive to potato matters as the growers themselves; their interests are now wider than just a mere business transaction. The training course which was inaugurated in 1945 has become an annual summer course for those representatives of seed potato firms who are members of the National Association of Seed Potato Merchants. In the past a similar training course has been provided each year for the Area Supervisors of the Potato Division of the Ministry of Food and will be continued on similar lines for the Potato Marketing Board.

Both the courses and the plots attract potato growers from all parts of the country as well as numerous overseas visitors, and are of permanent benefit to the potato industry.

THE GROWTH OF THE POTATO PLANT AND ITS EFFECT ON APHID INFESTATION

C. E. Taylor

The role of aphids in the transmission of the more serious virus diseases affecting the potato is generally recognised. An aphid feeding on an infected plant sucks up some of the sap containing the virus. When the aphid moves to a healthy plant and feeds on it, saliva containing the virus is injected into the plant which then becomes infected. Since not all crops of potatoes become infested in the same way, and the pattern of infection may vary from year to year even in the same variety, investigations are being made at the School of Agriculture in an attempt to find the reasons for these variations. Some results have already been published[1] [2].

The extent to which a potato crop is colonized is dependent in the first instance on the numbers of winged migrants which reach the crop from the sites where they have overwintered. This spring migration is largely governed by meteorological factors. Once having arrived on the plants, however, the subsequent behaviour of the migrants (and their progeny) is affected not only by microclimatic conditions, but also by their response to certain 'plant factors'. The distribution of aphids on potato plants has been studied by relating changes in aphid populations to changes in plant growth.

Growth of the potato plant.

Three stages in the general course of growth of the potato plant may be identified :

1. First the extension of the main shoot and the expansion of the attendant leaves. During this period all varieties used were found to have similar relative leaf-growth rates.
2. The second stage covers the period from the rapid development of the axillary shoots above ground, and stolons below ground, to the time of maximum leaf area.
3. The third stage extends from the time of maximum leaf area until the haulm and roots are dead and the tubers are fully formed.

The basic growth form of the potato plant is defined by the production of a main stem terminating in a flower cyme, below which a total of 26 nodes have been differentiated. The proportion of above-ground axillary shoots to the number of stolons below ground varies with each variety. In an early variety such as Ulster Chieftain there is an early development of stolons and a correlated slow production of axillary shoots. This results in early bulking of tubers but with a relatively low maximum yield, presumably due to the small assimilative area of the haulm. In the variety King Edward, on the other hand, tuber formation is delayed while there is a rapid growth of axillary shoots above ground. This results in a large total leaf area for assimilation and associated with this is a relatively large yield of tubers. Of the other two varieties studied in detail, Stormont Dawn was similar in its growth habit to King Edward, while Arran Pilot lay somewhere between the two extremes, production of tubers and formation of axillary shoots being more or less balanced so that a medium sized haulm was produced with fairly early bulking of tubers.

These differences in growth between the varieties were taken into account in evolving a method for sampling aphid populations. Leaves were taken from selected leaf-zones on the main stem and from the axillary shoots. Axillary shoots were also classified according to the node on the main axis from which they originated. In this way the distribution and development of the aphid infestations was interpreted in relation to the vegetative development of the plants.

The distribution of aphids on the plants.

The focus of the initial colonization by *Myzus persicae* (Sulz.) is invariably on the lower leaves of the main stem, the infestation then developing in relation to the senescence of the leaves. Usually

the infestation spreads upwards on to the middle leaves as they pass into the senescing stage and outwards on to the axillary shoots, where the leaves are undergoing a growth cycle similar to the leaves on the main stem. Selection of leaves within a certain physiological range by *M.persicae* is emphasized by the evidence of heavy infestations occurring on leaflets which were prematurely senescing due to mechanical injury, although forming part of a mature leaf. This spread of infestation from the lower part of the plant is not due to lack of movement on the part of the aphids for the wingless adults frequently move from leaf to leaf so that they are quite capable of infesting any part of the plant if it is suitable for them.

Macrosiphum solanifolii (Ashm.) also shows a preference for a particular leaf type, this species being found on the young, growing leaves at the tips of the shoots. On the other hand, although colonies of *Aphis nasturtii* (Kltb.) are normally found on the lower leaves of the plants, the spread of the infestation cannot be related to the physiological age of the leaf. In 1952, when particularly large populations of this species built up on the experimental plots it was shown that the dispersal of colonies depended mainly on the saturation density of the population which the leaf could support. It appears that *A.nasturtii* infestations are limited only by the size of the growing plant.

Differences in aphid infestations between potato varieties are thus related to the growth habits of the plants. With a quick maturing variety such as Arran Pilot, which presents a large number of senescing leaves during the period of the initial aphid colonization, larger populations of *M.persicae* would occur than on the other varieties. Since *M.solanifolii* prefers young leaves at the tips of shoots, a variety such as King Edward with a large number of axillary shoots would support correspondingly large populations. With favourable weather, *A.nasturtii* infestations are limited only by leaf area. Hence varieties with large haulms such as King Edward and Stormont Dawn usually carry heavier infestations of *A.nasturtii* than Ulster Chieftain or Arran Pilot. At present it would appear that the infestation of a potato plant depends on preferences shown by the aphid species concerned, and the developmental physiology of the plant.

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GRASSLAND UTILISATION AND EVALUATION

J. D. Ivins

Grassland occupies roughly two-thirds of these islands and is undoubtedly the cheapest food for livestock, and the improvement of grassland offers tremendous possibilities for increasing the production of meat and milk and lowering their costs of production. The techniques of grass production are now well understood and large quantities of herbage can be produced under almost any conditions in Great Britain. Consequently greater attention has more recently been focussed on the utilization and evaluation of this herbage when produced. A report has been published[1] of the initial investigations undertaken to determine the relative palatability of a wide range of the more productive herbage plants, that is, to study the reaction of the animal to strains and species which were deemed satisfactory in other respects such as herbage production, persistency etc. It was found that species and strains of herbage plants differed widely in respect of palatability. In the field such differences were found to materially determine the relative quantities of herbage consumed by grazing animals, and in consequence the output of animal products from varying swards. Relatively unpalatable strains of particular species, although giving high yields of green material, for example, S. 143 Cocksfoot, proved of less agricultural value than their botanical characteristics would suggest. An attempt was made to relate palatability to chemical composition but the results were inconclusive although both nitrogenous fertilizers and the presence of white clover improved palatability. Miscellaneous herbs such as ribgrass (*Plantago lanceolata* L.) were of highest palatability and in view of this evidence and our uncertainty as to the ability of the grazing animal to select those species of herbage plants which are of greatest value to it, the practice of sowing herb strips in leys intended for grazing is commended. The logical development of this work was then to compare the relative merits of different grass production methods in terms of animal production, for the value of grassland is essentially dependent on the quantities of livestock products, yields which are themselves equally dependent on the characteristics of the livestock.

Thus techniques have had to be explored which would counteract the wide variation between individual animals in order to obtain data for grassland production which could be validly compared. The outcome of this work has been an elaboration of the utilised starch equivalent method. When dairy cows are used to measure the

production of grassland, variations in respect of time of calving, age in lactations and innate ability of the animal to utilise grass, frequently mask the difference which might be occasioned by grassland treatment. Thus the standardisation of animal performance, particularly in respect of time of calving, is necessary in order to obtain an estimate of grassland output which would bear valid comparison with other figures, and a method has been obtained, whereby such standardisation can be effected[2]. Simultaneously data have been collected concerning the quantities of herbage which grazing animals will consume and the residues of herbage following intensive grazing. From these results procedures for maximum utilization of herbage by the use of strip grazing techniques have been suggested[3]. The influence of varying rest periods, on subsequent productivity is under investigation.

The problems encountered under conditions where the herbage is cut for conservation are vastly different from those where grassland is grazed. Under the former conditions defoliation occurs much less frequently and consequently white clover finds it difficult to persist. Moreover there is no return of dung and urine. Investigations have been carried out to determine the role of white clover under such conditions and the inter-relationship of white clover and nitrogenous fertilisers. Moderate dressings of fertilizer may, by suppressing clover, reduce the herbage production over the whole season although giving higher yields at first[4].

The establishment of a herd of identical twin cattle at the School has provided opportunity to evaluate grassland husbandry techniques much more accurately by a tremendous reduction in the variability of livestock. This allows finer issues such as the comparative merits of herbage plant species and strains and the influence of management procedures on subsequent productivity to be determined. The twin cattle are yet in the rearing stage and during 1955 the evaluation has been in terms of rate of growth and liveweight increase while in future years milk production will be the basis of comparison. Having established the "weighbridge for grassland evaluation"—viz. the herd of identical twins—the effects of many grassland techniques are being determined. In this way it is hoped to obtain quantitative data which are at present virtually non-existent.

Maximum utilization of herbage demands efficient conservation and to this end experiments are in progress, using an electrically operated grass drier, to produce material of high feeding quality at relatively low cost. The technique of drying, the mixtures of herbage suitable for such techniques, the costs of drying, losses during drying

and quality of the resultant product are among the issues under investigation.

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HYPOVITAMINOSIS A.

G. E. Lamming

There are two periods in the life of a farm animal during which a lack of Vitamin A can seriously affect normal body function. The first period commences during the last one third of pregnancy and extends for the first few months after birth. During this period maternal vitamin A deficiency may restrict the availability of this essential nutrient to the foetus or young animal with severe consequences. The second period occurs when farm animals reproduce for the minimum requirement of vitamin A for reproduction is four to five times the minimum requirement for growth[1].

In spite of the lack of fundamental knowledge on the role of vitamin A in body functions, certains abnormalities in farm animals have been definitely linked with lack of dietary carotene (provitamin A). These include premature births in cattle, night blindness, muscular inco-ordination and ataxia (staggering gait) in several species, and the often quoted sign of Xerpthalmia[a] in calves and laboratory animals which only occurs after prolonged vitamin A deficiency. Apart from the work on the role of vitamin A in the visual processes[2] there remains a vast field for study on the function of vitamin A in mammalian growth and reproduction. The finding of Moore and his co-workers [3] [4] [5] that cerebrospinal fluid pressure increased due to vitamin A deficiency in calves has led to studies of this disease in the incipient or sub-clinical stage. It is this stage of deficiency which may be most important in farm practice, rather than severe deficiency where secondary effects may come into the picture.

(a) Xerophthalmia : inflamation of parts of the eye producing an abnormally dry condition of the eyeball.

Attempts have now been made to analyse these effects further, using rabbits as experimental animals, and it has been possible to produce signs of vitamin A deficiency at the two stages mentioned above, which resemble those previously observed in farm animals. These signs have already been fully reported,[6] [7] and are briefly described here.

The female rabbit with sub-clinical vitamin A deficiency will continue to show signs of oestrus and will usually mate. There is a slight decrease in conception rate following mating, and a further decrease in the number of eggs implanted although there appears to be no abnormalities of implantation[6]. In spite of the decreased size of litter which follows the average size of the individual foetus half-way through pregnancy and just before parturition was found to be significantly less than normal. This suggests that foetal nutrition is adversely affected by maternal vitamin A deficiency. The frequent abortions and foetal resorptions in the deficient groups were similar to those due to lack of progesterone. In a further experiment it was shown that if daily injections of progesterone were given sufficient to supply the total daily requirements of the pregnant rabbit, no abortions occurred. This finding requires confirmation.

Attempts were made to discover the underlying causes of these signs of vitamin A deficiency. Histological examinations of the thyroids and adrenal glands revealed no noticeable changes. In vitamin A-deficient cattle causes of cystic pituitary have been observed elsewhere, and in laboratory animals there are reports of changes in the gonadotrophic potency of the pituitary gland, but using day old male chicks as assay animals, it has not been possible to confirm this.

More recently, the effects of maternal vitamin A deficiency on pre-natal and post-natal growth of the young rabbit have been investigated. Does with sub-clinical deficiency were allowed to kindle normally and rear their young, but in some of the litters nervous abnormalities developed from three to eight weeks after birth[8]. Some animals showed characteristic head retraction and ataxia (staggering gait), while many others showed no such symptoms but on autopsy were found to have gross brain lesions. The neurological abnormalities were investigated and comparisons made with similar young from rabbits receiving the same diet plus vitamin A supplements[9]. The majority of affected young had severe hydrocephalus [b] and it is postulated that it is due to an increased production of

(b) Hydrocephalus: an abnormal increase in the amount of cerebral fluid with dilation of the cerebral ventricles, sometimes accompanied by atrophy of the brain and convulsions.

cerebrospinal fluid which increased the cerebrospinal fluid pressure and frequently caused blockage of the cerebral aqueduct.

We have further examined foetuses obtained from vitamin A-deficient does at the 29th day of gestation and young stillborn to does with sub-clinical deficiency. A high percentage of these young had severe hydrocephalus[10].

It has not been possible to confirm earlier suggestions that abnormalities of bone development leading to compression of the nervous system are responsible for the signs of vitamin A deficiency in young animals[11] [12] [13]. We could find no abnormalities of bone growth in rabbits and the occurrence of hydrocephalus in pre-natal young seems hardly compatible with the view that abnormal bone development is the underlying cause. It seems likely that the papilloedema or compression of the optic nerves observed by previous workers[14] [15] may be a driect result of increased C.S.F. pressure in the region of the optic foramina[9].

Preliminary experiments have shown that dilation of the ventricles of the brain occur in calves fed from birth on a diet low in carotene and vitamin A. Further investigations are underway to discover at what stage of gestation in rabbits the hydrocephalus develops and whether or not vitamin A therapy can prevent the occurrence of hydrocephalus in the young. Other work has shown that the pathology of sway back in lambs is very similar to hydrocephalus associated with maternal vitamin A deficiency and raises the question whether this may be the unknown link in the aetiology of sway back. This problem is now under investigation.

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THE ANTI-BACTERIAL ACTIVITY OF THE OESTROGENIC HORMONES AND THEIR ANALOGUES

M. Woodbine A. Seaman and G. E. Lamming

The association of anti-bacterial activity with the sex hormones does not appear to have been examined extensively. Reports based on a broad survey of the post—1914-18 literature appear to be controversial but, in general, it may be stated that there appears to be some association between the sex hormones and anti-bacterial activity particularly with the oestrogenic hormones and their analogues, namely oestrone, progesterone and stilboestrol. The natural hormones have a greater, but as yet indefinable, activity *in vivo* and the synthetic products *in vitro* ; but there is no clear demarcation between them.

The influence, association, and relation between ovarian hormones and uterine infection, notably of cattle, has recently been considered[1] [2] [3]. Evidence has been presented that the relative **resistance** of the bovine uterus to experimental infection during oestrus and the relative **susceptibility** during the luteal phase, are due to

oestrogen or progesterone. In addition, experimental uterine infections could be controlled by administered hormones. The physiological basis for such changes in the resistance to uterine infection relative to the ovarian hormone status is at present unknown.

It attempts to demonstrate the presence of growth-promoting or-inhibiting substances, we[4] have presented some preliminary observations on the effect of blood, serum, uterine tissue and exudate of rabbits and cows, on the growth of the bacterium *Corynebacterium pyogenes*, which destroys (or haemolyses) blood. Strips of uterine tissue or swabs from the uterus gave increased zones of haemolysis on blood agar containing *C.pyogenes* when they came from a cow in the follicular phase, an anoestrus cow, or a rabbit treated with stilboestrol. On the other hand, no haemolysis developed with uterine tissue or swabs from an anoestrus rabbit, cows in the luteal phase, or rabbits 3-6 days post-ovulation. Nor were zones apparent on horse, cow, or rabbit blood agar in the absence of the *C.pyogenes* whatever the origin of tissues or swabs. This increased lysis was found in circumstances which might have been expected to show **resistence** to infection—in which event **less** lysis (which is due to the growth of*C.pyogenes*) would have been anticipated. The zone disappears as normal growth of the organism in the rest of the plate causes total lysis of the blood. The zone might, therefore, be due either to a local increase in the growth of *C.pyogenes* or to death releasing an internal haemolytic substance.

Efforts to try to decide whether these results are due to any specific antagonistic, or stimulatory, effects of the sex hormones or their analogues are to be made. But it is tempting to speculate whether casual uterine infection or for example, infections due to *Vibrio fetus*, might be controlled eventually by a synthetic product which, while being anti-bacterial, may or may not be oestrogenic.

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PROTEIN LEVELS IN POULTRY FEEDING

R. B. Shaw

Over twenty years ago a series of experiments were conducted in Northern Ireland in which poultry given a ration without any protein supplement produced more eggs than birds receiving a high-protein diet. These results were confirmed in experiments conducted at Sutton Bonington in 1934-37.

The desirability of again experimenting on protein levels was made manifest in the immediate post-war period when farmers were urged to keep more poultry for egg production at a time when the supplies of animal and vegetable protein were very limited. It was still the accepted practice to supplement a layers' mash with 8 to 10 per cent of high quality animal protein, or about 6 per cent animal protein plus some vegetable protein. If it could be demonstrated that little or no extra protein was necessary, particularly under free range conditions, it was probable that farmers would be encouraged to increase their poultry.

During the rearing seasons of 1949 and 1950 the possibility of rearing pullets with access to grassland on a simple diet to which no protein had been added was demonstrated at Sutton Bonington. Apart from the slower growth which delayed sexual maturity by about three weeks the results were quite satisfactory.

Initially, the experiments on egg production were restricted to pullets in slatted floor houses and with access to limited grassland of moderate quality. A diet without any protein supplement was compared with the same diet plus bean meal and a more orthodox diet containing fish meal. The experiment was then extended to pullets in fold units moved daily over pasture land. The results from the low protein diets were most satisfactory in several directions : (i) egg size, (ii) food consumption, (iii) health, and although winter egg production was inclined to be below that from the more complete diet the total production was on occasion higher. Even in years when the birds on the more normal diet produced more eggs than the others, the cost of the animal protein used was so high as to offset the advantage gained. This emphasised the importance of feeding the optimum amount of protein and so the next step in our work was to try other levels of animal protein ; it was also decided to include birds kept in cages and away from grassland. Again there was evidence that protein fed in amounts much less than was customary in the past could give as good egg production at less cost. The results have been described in detail elsewhere[1].

The variation in the protein level appeared to have little effect on the hatchability of the eggs produced, those on low protein diet gave 80.4% hatchability and the others on the higher protein diet 71.2%. These results are in accordance with those published from other centres[2].

With table poultry, the results were not conclusive, the diet relatively rich in animal protein encouraged quicker growth, and the birds on it consumed less food, the difference was not enough to cover the increased cost, nor was there any improvement in carcase quality.

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STUDIES IN PIG PRODUCTION

J. T. Morgan and M. J. Manners

The pig enterprise initiated with a modest nucleus of foundation pedigree Large Whites in 1930 had developed into a 50 sow unit by 1939. It was reduced during the war years and has in recent years been comprised of 20 sows from which the progeny are fed for bacon production. Breeding stock has normally been maintained outdoors in grass paddocks or more recently in fold units incorporating arrangements for creep feeding of sucklers. Litters are suckled for eight weeks and are subsequently transferred to fattening premises.

Recently an analysis has been made of the records of the pig enterprise over the last 20 years. Statistical data were available on some 10,000 pigs comprising 919 litters including 12 litter sequences.

Selection of Breeding Stock.

Analysis of production records of 340 sows showed that almost 40 per cent were culled because of unsatisfactory prolificacy or low weaning weight of piglets · 25 per cent culls because of age, whilst disease, mainly chronic erysipelas accounted for 22 per cent. The remaining 13 per cent included sows culled because of infertility, injury and other miscellaneous causes.

The following table (Table 1) represents wastage in relation to breeding record :—

TABLE 1. DISPOSAL OF SOWS IN RELATION TO No. OF FARROWS.

Farrow No.	1	2	3	4	5	6	7	8	9—12
% Culls	5.0	21.4	18.5	5.5	8.8	10.5	5.9	4.2	9.3
Accum. % Culls	5.0	26.4	44.9	61.3	78.1	80.6	86.5	90.7	100.0

These figures imply a replacement rate of 25—30 per cent with each successive litter sequence. Analysis of the relevant data showed that some 50 per cent of these replacements were selected from dams which had produced only two litters and over 70 per cent from dams which had produced four litters or less. The number of females in any age class determined the number selected from that class. It is clear that no serious attempt has been made to select for longevity.

Prolificacy was found to increase with litter sequence reaching a maximum in 3rd litters and thereafter remaining fairly stable for some 5 successive litters. Weaning numbers on the other hand, were maximal in 3rd litters, and thereafter decreased. The optimum age for first mating was found to be about nine months.

The average length of life for males was 27.07 months and some 62.8 per cent herd sires were selected from 1st or 2nd farrows. Selection of sires, as in many English herds, has been on the basis of individual phenotype, rather than on ancestral performance.

Performance of Suckling Piglets.

Suckler productivity is essentially a reflection of some sow performance characters. Numerous investigations have shown that heritability of many of the latter is of a low order, and therefore the evaluation of the significance of the several components of environmental influence is of the utmost importance in designing practical management methods, and the formulation of breeding plans.

80 per cent of the total mortality of piglets was found to occur in the first week of life and was related to a considerable extent to docility and "mothering ability" in the sow. Survival of piglets in summer litters (75 per cent) as compared with winter litters (55 per cent) amply demonstrates the importance of provision of good housing.

Litter size is also of significant effect on the mortality rate of sucklers. Litter size at weaning was found to be largely dependent

on numbers born up to 12 pigs, but thereafter weaning numbers decrease and the percentage mortality figure is of the order of 50 per cent in litters of 18—20 pigs.

The attainment of high birth weight is of the utmost importance since birth weight is positively correlated with weaning weight. Persistent effects of maternal environment during the subsequent feeding period lead to earlier age at slaughter and improvement in carcass quality. The nutritional status of the dam during pregnancy was found to be of little importance. No relationship could be found between the indices of litter performance and liveweight changes of the dams.

Total litter weight was positively correlated with litter size, and as would be expected, a significant negative correlation was obtained between litter size at birth and average piglet weight. Pilot observations on suckling pigs have shown that the addition of antibiotic (Aurofac), or sugar at a 15 per cent level to creep feeds is beneficial in stimulating growth.

Extensive observations have been recorded on the behaviour of suckling pigs. Although there is no relationship between birth weights and teat position acquired, there is distinct competition for the anterior teats which are superior in merit (Table 2).

TABLE 2. EFFECT OF TEAT SUCKLED ON RATE OF GROWTH.

Teat pair No.	1	2	3	4	5	6	7
No. of Piglets	129	116	115	105	61	58	12
Av. 21 day wt. lb.	13.54	12.72	12.30	12.28	11.32	11.25	9.63

The desirability of attaining maximum litter size in early litters is indicated by the finding that teats consistently suckled have a higher milk potential than those not suckled during any individual lactation.

Nutrition of Fattening Pigs.

It is now common practice for some form of quantitative restriction of feed intake to be adopted in the latter stages of the fattening period in order to improve the grading of the carcass at slaughter. However, in many cases housing design does not allow of implementation of this technique and nutrient intake can be controlled only by qualitative variation in rations fed. The results of pilot observations (Table 3) show that qualitative restriction of nutrient intake

by using foods of fibrous nature may be expected to result in an improved carcass grading. There is also an impaired efficiency of food utilization. This would not normally be important in that the individual foods used should cost less per unit nutrient. However, at present this may not obtain, in that for example Millers Offals are as costly as Barley Meal, but other fibrous foods could be used instead. In this case there was a reduction in fat quality, as shown by the higher iodine values obtained for fatty tissue in the groups which were fed on the more fibrous food mixtures, but in no case did this result in the levy of any monetary penalties.

It seems likely that adoption of the technique of qualitative feeding restriction when housing design does not allow of implementation of the usual method of quantitatively restricting feed, offers a partial solution to a common and important management problem.

TABLE 3.

Group	A Balanced meal (av. 6.3% crude fibre), fed to appetite.	B Balanced meal (av. 6.3% crude fibre)—Restricted feeding (max. 6lbs. per day)	C Fibrous meal (av. 8% crude fibre to 120 lbs. lv.wt. 12.4% crude Fibre 120 lbs. — slaughter), fed to appetite	D Fibrous meal (av. 8% crude fibre to 140 lbs. lv.wt. 12.4% crude fibre 140lbs. — slaughter), fed to appetite
No. of Pigs	14	11	16	12
Av. initial weight, lb.	74.9	75.0	71.7	72.0
Av. liveweight increase in first 70 days of experiment, lb.	103.1*	88.7	84.9	93.3
lb. meal consumed/lb. liveweight increase (over a 10-wk period)	4.36	3.54	5.30	5.07
Av. carcass weight, lb.	159.6*	153.8	148.8	151.1
Backfat thickness adjusted for differences in cascass weight (sixteenths of an inch)				
Mid back	18.3*	16.2	16.8	15.9
Loin	20.6*	17.6	18.0	17.6
Shoulder	34.5	30.3	31.2	30.7
Iodine value of fatty tissue†	52.2*	57.0	60.6	59.2
No. of baconers in payment grade :—				
1	8	9	14	11
2	5	2	2	1
3	1	—	—	—
Av. price received shillings per ccore (D.W.)	53.06	54.40	54.64	54.72

*The differences between Group A and the other three groups were significant in these cases.

†The higher the iodine value the softer the fat.

LABOUR PRODUCTIVITY IN VEGETABLE PRODUCTION

K. A. Ingersent and T. K. Warley

The type of horticulture most characteristic of this region is the production of outdoor vegetables, a high proportion of which are grown on a farm-scale. Over the period from 1950-51 to 1952-53, a total of approximately 31,000 acres of **all** horticultural crops were grown in the East Midlands Province each year, with an estimated gross value of rather less than £4 million to the grower, "at the farm gate". During the same period the area under **out-door vegetable** crops averaged nearly 26,000 acres per annum, with an estimated gross value of the order of £2½ million to the grower. Thus in recent years, outdoor vegetables have accounted for over 80 per cent of the acreage, and about 60 per cent of the gross value to the grower of all the horticultural crops grown.

There are two important features of vegetable production in the East Midlands. First a high proportion of the total acreage of out-door vegetables are grown on a farm-scale. An analysis of the 1947 June Returns has revealed that at that time 64 per cent of the outdoor vegetable acreage was on holdings of 100 acres or greater. Secondly, a relatively small number of particular kinds of vegetable account for a high proportion of the total acreage and production of vegetable crops. Over the period from 1950-51 to 1952-53, six kinds of crop comprised over 80 per cent of the total acreage of vegetables in the East Midlands: these were cabbages (including savoys), carrots, pulling peas, vining peas, cauliflowers (including winter broccoli), and brussels sprouts in that order.

An investigation of the productivity of labour associated with the culture of these six vegetable crops, particularly on the larger farms, has been undertaken. This enquiry was planned in two main stages. First, a survey was designed to obtain a broad picture of the utilization of labour in the production of each of the crops, this being carried on over two consecutive cropping seasons. The principal objectives at this stage were to obtain some measure of the **total quantity** of labour used in the production of a crop, and the extent to which this varies between different farms employing different practices and techniques; to ascertain how the total labour required for producing the crop is distributed between the principal growing and harvesting operations, the dates at which these operations are performed; and possibly to pin-point the most labour consuming operations; it was also intended to assemble information concerning the extent to which specific types of labour are employed to perform

particular operations. Thus, casual labour was to be recorded separately from regular labour, male workers from female workers, and piece-workers from day-workers.

In the second main stage of the enquiry, it was intended to select key operations which seemed to offer scope for a substantial degree of labour saving, and to subject these to detailed examination **in the field** with a view to uncovering reasons for differences in rates of work performance either between different gangs of workers on different holdings, or between different individuals composing a gang on a single holding.

At the time of writing, the first stage of the enquiry is nearing completion. The survey of the first season's production of each of the six vegetable crops has been completed, the results have been subjected to preliminary examination and interim growers' reports on each crop have been distributed to those who participated in the survey. The survey of the second season's production has been completed for the autumn cauliflower crop, and a second growers' report has been issued for that crop summarising the tentative conclusions arrived at as a result of the two seasons' working. The second season's survey of the remaining five crops will be completed by the autumn of this year.

Interim results—The Autumn Cauliflower Crop.

Stage 1 of this enquiry has now been completed for the autumn cauliflower crop and furthermore, it is with this crop that Stage 2, the observation and analysis of key operations in the field, is at the most advanced stage. For these reasons, a summary of the preliminary findings concerning this crop will be given here as an example of the sort of results which this enquiry may be expected to yield.

The analysis of the data obtained during the two years' survey suggested a number of ways in which growers might be able to reduce labour costs. These fall into three main categories :—

1. Elimination of tasks.
2. More efficient accomplishment of certain tasks.
3. Increased yields.

1. Elimination of Tasks.

(a) **Choice of preceding crop.**

It has been established quite clearly that autumn cauliflowers grown after early potatoes generally entail substantially lower labour

requirements, during the growing stage of the crop, than autumn cauliflowers grown after other crops. This saving of labour is effected at two stages. Firstly, preparatory cultivations are generally reduced to a negligible amount : ploughing in these circumstances is exceptional, and most growers simply harrow the land level before planting. Secondly, hand hoeing and other cleaning operations can be greatly reduced by following directly after a "cleaning crop". The actual magnitude of the saving will, of course, vary according to individual farm conditions, but on average we estimate that it is somewhere in the region of 17 man hours (or 2 man-days) per acre of autumn cauliflowers. In addition, there is an average saving of 5 machine hours (implements powered by tractor or horses) per acre.

(b) **Method of crop disposal.**

As with the majority of crops, the harvesting operation absorbs a very high proportion of the total labour requirements. However, in the case of the autumn cauliflower crop growers in some areas can relieve themselves of the responsibility for finding the large amount of labour required for this operation by arranging for the buyer to do the cutting. Where this arrangement is made, the grower's sole responsibility is normally that of assisting with the removal of the cauliflowers from the field to the nearest hard road ; and under some circumstances even this responsibility may be avoided. In numerical terms, the average saving in **grower's** harvesting labour, where the crop is cut by a merchant was just over 50 man hours and 2 machine hours per acre. The magnitude of the saving depends very much, of course, on the size of the crop and the above figures are based on an average yield slightly in excess of 400 crates per acre.

It may also be added that the financial results of the survey provided little or no evidence to suggest that over a number of seasons the grower who markets the standing crop will be any worse off **financially** than the grower who cuts the crop himself.

2. More Efficient Accomplishment of Task.

The results of the survey showed clearly that apart from harvesting, transplanting was the key labour-consuming operation in autumn cauliflower production. It was for this reason that we decided to subject this operation to further study in the field.

It is now generally accepted that with a labour force of four or five persons transplanting can be carried out more quickly and more cheaply by machine than by hand. Our objective therefore was not to compare the relative efficiencies of hand versus machine planting

but to reveal the extent of differences between growers in the efficiency of transplanting machine use. As a result of one season's study of the problem, our conclusions concerning efficiency in the mechanical transplanting of autumn cauliflowers are briefly as follows.

The objective of mechanical transplanting is to establish a given plant population as quickly and as cheaply as possible within the limits imposed by a limited supply of labour. Achieving the desired plant population is of the utmost importance because if the number of plants is seriously different from that is intended the market value of the crop is likely to be adversely affected. This is particularly so if the actual plant population is less than that which is intended. Hence even spacing of the plants at the correct planting distance, and a minimum number of "gaps" are two of the essentials of efficient planting. The solution to inaccurate spacing in the row lies in making frequent measurements to detect inaccuracies, and varying the tractor speed accordingly. The incidence of gaps in the plant rows can be reduced by the use of a simply constructed plant-platform which any grower may fit to his machine, and which ensures that the planters have a constant supply of plants ready to hand without the direct intervention of "the feeder".

The speed of planting is largely determined by tractor speed, and by the number of units on the planting machine. But tractor speed is limited by the skill of the slowest planter and the maximum tractor speed permissible is that which will just allow the slowest planter to space the plants correctly in the row. Other things being equal the output of a 2-unit machine is lower than that of a 3-unit machine, but skilful planters on a 2-unit machine are capable of a higher output than that achieved by a less skilful team on a 3-unit machine. The skill of the individual planter depends in the last resort on inherent dexterity, but this may not be developed to full capacity unless inexperienced workers are given adequate training with regard to such matters as a comfortable posture which minimises the amount of fatiguing body movement.

The rate of planting also depends to some extent on the plants, particularly on how well they are sorted before the planter receives them. This is the responsibility either of the people who lift the plants or, where such a worker is employed, of the "feeder" riding on the machine. However, observations made on several farms have convinced us that under some circumstances it is quite feasible to dispense with the feeder without adversely affecting the speed or quality of planting. This may be brought about by means of either

of two very simple devices which enable sorted plants to be carried on the machine near enough to each planter's "holding hand" for him to be able to replenish the supply for himself, each time a fresh handful is needed, without interfering with the rhythm of his work. For those who have not yet adopted it, this seems to be one of the most promising ways of reducing the cost of mechinical transplanting.

3. Increased Yields.

If higher yields can be secured through improved management practices, the productivity of labour will be improved if the increased value of the crop is greater than the cost of the additional labour and materials required to grow and harvest it. This will normally be the case because, although harvesting costs are roughly proportional to yield, non-harvesting or growing labour requirements are by no means so closely related to yield. In fact non-harvesting labour requirements may be regarded as a "fixed cost" which is of much the same magnitude whether yields are high or low[1]. This is because the securing of good yields depends not only on **what** is done but **how** it is done and **when** it is done.

Improved management practices that might be expected to secure yield increases, at least in the long run, include the use of good strains of seed, care in lifting and transplanting, planting in the correct soil conditions, and making sure that the intended plant population is actually obtained.

On the basis of information obtained during the course of the survey it has been calculated that on average total labour requirements **per crate** are likely to be 40 to 45 per cent higher for a 200 crate to the acre crop than for a 600 crate to the acre crop.

Expected Future Developments.

The two season's survey of each of the five remaining vegetable crops is expected to yield results of the same type, although naturally different in detail, to those described for the autumn cauliflower crop.

With regard to Stage 2 of the enquiry a comparative study of carrot harvesting by hand and by mechanical methods was started last autumn, but unfortunately adverse weather conditions reacted unfavourably on this work. However, it is hoped that it will be

(1) This is not to say that non-harvesting labour requirements are the same everywhere ; only that given a farm under a particular system of management, and with a particular set of growing practices and techniques, much the same amount of non-harvesting labour is likely to be required irrespective of whether the final outcome is a high or low yield.

possible to pursue this part of the investigation further this year. In addition we hope to make a special study of the harvesting of vining peas, which is already mechanised at the cutting stage on most farms, but which is mechanised at the loading stage on comparatively few farms.

THE WEATHER DURING 1954 AND 1955

T. Webster, N.I.A.B. Regional Trials Officer

Weather in 1954.

Casual impressions of the weather can be very misleading, but the general belief that 1954 was a wet, cold year, is largely confirmed by the records. The first three months were not exceptional. January was rather sunnier than usual, but there was little snow during the period, and frosts were not very severe. April was very dry indeed, the rainfall being the lowest since 1938. From May to September conditions were mostly dull and cool, with above average rainfall. During the last three months, temperatures were higher, but, until December, rainfall was still above average. The more detailed pattern of the weather shows that extreme variations from normal were uncommon, and that the bad weather was often the result of relatively small variations consistently maintained. Table 1 shows the main data for the period, with appropriate comparisons with average.

Rainfall.

Despite the generally wet year, no one month can be singled out as being extraordinarily wet. Even the November rainfall, which was almost 2½ times the average, was exceeded in 1951, while the rainfall in the next-wettest months (February, May, June and August) has been exceeded several times during the previous nine years. Only four months, however, had a rainfall below average, and if the exceptionally low figure for April is excluded, the total for the remaining eleven months was 35% above average.

Sunshine.

Sunshine was above average during six months, though four of these were winter months. There was little sunshine from May to October, lower figures being recorded only rarely in the previous nine years.

Temperature.

The mean air temperatures for the first nine months were almost consistently below normal, the grand average for the period being 1.9°F below normal, in contrast to the last three months, which averaged 2.8°F above. The very mild weather late in the year prolonged the growing season, and possibly compensated somewhat, as far as crop yields were concerned, for the poor summer. The soil temperatures followed a similar pattern, and except for the temperature at 2′ for a short period in January, were consistently below average until late September, the largest deficits occurring in July and August. There was a considerable improvement during the last three months, and the year ended with soil temperatures 3°F, and mean air temperature 4°F above average.

Crops.

The effect of the year's weather on crops was surprisingly slight. Winter beans were badly damaged by freezing winds during February, and did not recover well; mildew on cereals was worse than usual, and there was considerable lodging; potato blight appeared earlier, and became worse than normal; but in most cases yields were resonably good. One of the most serious effects of the prolonged wet weather in the autumn was to delay the sowing of winter cereals, or cause it to be done under poor field conditions.

Weather in 1955.

The weather during the first half of 1955 was rather mixed. There was a late spring, with snow lying well into March. April was generally rather warm, but May and June were cool, changeable and wet. The rest of the year was unusually dry, and apart from rather severe frosts in October, the winter was mild.

Rainfall.

The first four months were not unusual, only the March rainfall being much above average. May and June, however, were exceptionally wet, rainfall being even higher than in the corresponding months in 1954, by over an inch in each case. July and August were very dry, and although the remainder of the year was not much below average, it was consistently so, and the soil only occasionally reached field capacity until November.

Sunshine.

Sunshine was above average during seven months, and was only much below average in June. March, July, September and December were particularly sunny.

Temperature.

The mean air temperature was below normal for five out of the first six months of the year, being particularly low in February and March, and again in May. Snow lying at the end of February took over ten days to clear completely, and there were seven occasions of ground frost in May. July was only slightly warmer than average. but except for October, air temperatures were above normal for the remainder of the year.

Apart from the temperature at 2′ during January and February, soil temperatures were below normal until July, particularly in March and May. There was a sudden rise following the hot dry weather in July and August, and a fall caused by sharp frosts in October, but the year ended with soil temperatures slightly above normal.

Crops.

Winter cereals were mostly winter poor, and were not helped by the cold weather during February and March. They recovered fairly well later, but yields were erratic, and generally rather below average.

In contrast, spring cereals did exceptionally well, and good yields were obtained, especially of spring wheat. Mildew and rust appeared late and were never more than a slight attack.

Potatoes suffered considerably from drought, and haulm ripening was often premature. Blackleg was common, but blight was not observed. Yields were poor. Sugar beet was often considerably wilted, and there was a moderate attack of virus yellows. The crop recovered to some extent in the autumn, and yields were reasonably good, sugar content being much above average. Conditions for sowing winter cereals were good, but despite fairly mild weather, brairding and early growth were slow.

TABLE 1. WEATHER DATA FOR 1954.

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR. No Period
A. Rainfall (inches)	1.18	2.02	1.63	0.26	2.46	2.62	2.01	3.99	2.09	2.93	4.46	2.00	27.65
Rainfall as % of average 1885—1915	72	145	112	19	140	149	93	177	139	126	242	91	127
No. of times rainfall exceeded in previous ten years	5	4	3	9	2	3	3	3	3	3	1	3	2
No. of rain days	14	19	15	9	16	15	19	22	22	20	23	15	209
Rain days as % of average 1946—1953	102	101	115	73	126	108	188	169	168	183	154	101	135
B. Total sunshine (hours)	54.6	60.7	90.4	141.0	109.8	122.8	147.4	114.5	170.3	78.1	54.7	49.2	1193.5
Sunshine as % of average 1921—1950	133	103	84	101	62	65	82	71	139	81	102	154	88
No. of times sunshine exceeded in previous ten years	1	3	4	7	9	8	9	8	1	6	4	1	9
C. Temperatures (°F)													
(1) Mean screen maximum	41.7	41.4	48.0	54.0	60.1	62.6	64.5	65.6	62.7	59.3	49.8	48.2	54.8
(2) Mean screen minimum	30.6	30.5	35.4	36.1	44.0	49.0	51.0	50.5	47.0	47.7	37.4	38.6	41.5
(3) Average of (1) and (2)	36.1	35.9	41.7	45.1	52.1	55.8	57.7	58.1	54.9	53.5	43.6	43.4	48.1
(4) Deviation from average 1921—1950	− 2.3	− 3.0	− 0.5	− 1.6	+ 0.1	− 1.8	− 3.9	− 2.4	− 1.4	+ 3.9	+ 0.6	+ 4.0	− 0.8
(5) Soil temperature at 4"	35.7	34.4	37.8	43.3	50.2	55.9	58.0	56.9	53.3	51.9	43.7	42.1	46.9
(6) Deviation from average 1946—1953	− 2.0	− 2.9	− 1.9	− 2.3	− 2.4	− 2.8	− 3.8	− 3.5	− 2.8	+ 2.7	+ 0.2	+ 3.1	− 1.7
(7) Soil temperature at 8"	37.4	35.6	39.5	44.2	51.4	55.6	57.8	57.2	54.4	52.5	45.0	43.0	47.8
(8) Deviation from average 1946—1953	− 1.1	− 2.5	− 0.8	− 1.4	− 0.6	− 2.0	− 3.1	− 3.1	− 2.3	+ 2.2	+ 0.5	+ 2.8	− 1.1
(9) Soil temperature at 2'	40.9	38.3	41.1	45.4	49.5	55.1	57.5	58.2	54.7	53.8	48.2	45.1	49.0
(10) Deviation from average 1946—1953	+ 0.9	− 0.9	− 0.5	− 1.5	− 3.3	− 3.2	− 4.5	− 3.6	− 4.1	+ 1.1	+ 1.3	+ 2.9	− 1.4

TABLE 2. WEATHER DATA FOR 1955.

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
A. Rainfall (inches)	1.50	1.40	2.57	0.99	3.60	3.78	0.90	0.29	1.08	1.87	1.61	1.50	21.09
Rainfall as % of average 1885—1915	91	101	177	71	205	215	41	13	72	81	87	68	97
No. of times rainfall exceeded in previous ten years	5	7	2	9	0	0	7	10	9	6	5	8	8
No. of rain days	13	16	12	10	21	11	3	4	11	12	10	17	140
Rain days as % of average 1946—1954	94	127	91	84	160	79	27	29	78	101	63	114	123
B. Total sunshine (hours)	35.3	75.5	130.8	144.1	185.7	128.8	246.4	149.0	151.1	118.2	49.2	45.1	1459.2
Sunshine as % of average 1921—1950	86	128	122	103	105	68	137	92	123	123	92	141	107
No. of times sunshine exceeded in previous ten years	7	3	1	6	3	8	0	6	2	0	8	4	1
C. Temperatures (°F)													
(1) Mean screen maximum	40.7	38.6	43.6	57.1	56.5	64.2	73.1	73.6	66.3	56.7	50.0	47.6	55.7
(2) Mean screen minimum	31.4	27.6	29.9	40.8	41 0	47.8	51.2	54.0	48.7	40.5	38.1	35.1	40.5
(3) Average of (1) and (2)	36.1	33.1	36.7	48.9	48 7½	56 0	62.1	63.8	57.5	48.6	44.1	41.3	48.1
(4) Deviation from average 1921—1950	−2.3	−5.8	−5.5	+2.2	−3.3	−1.6	+0.5	+3.3	+1.2	−1.0	+1.1	+1.9	−0.8
(5) Soil temperature at 4"	36.6	35.0	34.9	45.2	47.9	56.4	63.4	63.7	56.1	46.9	44.1	39.7	47.5
(6) Deviation from average 1946—1954	−0.9	−1.9	−4.6	−0.2	−4.4	−1.9	+2.0	+3.7	+0.3	−2.6	+0.6	+0.4	−0.9
(7) Soil temperature at 8"	37.7	36.4	36.0	45.3	47.9	55.4	62.8	63.6	57.3	48.8	45.7	41.0	48.2
(8) Deviation from average 1946—1954	−0.7	−1.4	−4.2	−0.2	−4.0	−2.0	+2.2	+3.6	+0.9	−1.8	+1.2	+0.5	−0.5
(9) Soil temperature at 2'	40.8	39.5	38.0	44.5	48.0	54.3	61.3	62.9	59.5	53.1	48.9	43.5	49.5
(10) Deviation from average 1946—1954	+0.7	+0.4	−3.5	−2.3	−4.4	−3.7	−0.2	+1.5	+1.1	+0.3	+1.9	+1.0	−0.7

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D. V. CRAWFORD :

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J. P. HUDSON :

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J. P. HUDSON, Mr. P. J. SALTER and Mr. A. M. MAJMUDAR :

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J. D. IVINS :

'Farmers—their policy', to The British Electrical Development Association Rural Electrification Conference.

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F. L. MILTHORPE :

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K. RASMUSSEN :

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R. SCOTT :

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C. E. TAYLOR :

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